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ART. XLIV.—*Elasticity of Ice;* by JOHN TROWBRIDGE and AUSTIN L. MCRAE.

APPARENTLY the only previous experiments made to determine the modulus of elasticity of ice are those of Benjamin Bevan.* He went to a pond where the ice was about ten centimeters thick and sawed one end and two sides of a beam, leaving the other end attached to the main body of ice. He then loaded the free end and obtained the absolute modulus 54×10^9. Nothing is said about the ice returning to its first position when the load was removed, nor of the deflection due to the weight of the beam itself. As the weight of the beam was four or five times the heaviest weight used, this deflection would be quite appreciable. The lower surface of the ice apparently rested on the water of the pond which prevented it from deflecting as far as it would have done. The upward pressure of the water would in part counterbalance the effect of the weight of the beam.

Methods of Observation.

We first endeavored to obtain the modulus by a direct pull on a bar. For this purpose water was put in brass tubes closed at one end and boiled so as to expel bubbles of air, then frozen, sometimes artificially, but generally by placing the tubes out of the window and allowing the water to freeze naturally. The

* Phil. Trans., 1826.

temperature of the air varying from −3° C. to −18° C. After it was thoroughly frozen, water from the water pipes was allowed to flow over the tubes. This expanded the brass enough to allow the cylinder of ice to be slipped out without appreciable melting.

Some of the cylinders looked homogeneous throughout, but most of them appeared to be very porous along their axes.

The bar was hung by a clamp at its upper end. At the lower end there was another clamp to which a scale pan was attached. A small fibre was fastened to the bar at the upper mark and terminated in a pointed plumb-bob. The fiber hung clear of the ice so that its length remained invariable and the yielding of the upper support made no difference. The increased difference in the readings of the plumb-bob and of the lower mark gave the elongation for a given weight. The increased length being so small and the least wind causing the fiber and bar to swing, the errors of observation were so large that this method was abandoned.

It may be interesting to note that a bar left suspended an entire day (temperature −13° C.) changed from a cylinder to a frustrum of a cone.

The next experiments were made to get the transverse vibrations of the ice. The bars were obtained in the same manner as in the previous method. A sewing needle frozen transversely to one end of the bar served as a pointer. The other end was firmly clamped. The clamp was cooled to zero before the ice was put in. A tuning fork was placed by the side of the ice and so arranged that the two pointers were on a line. The tuning fork and bar were then set in vibration and a piece of smoked glass drawn under the two pointers received the two curves. Knowing the rate of the tuning fork, the number of transverse vibrations of the ice was obtained by comparing the number in equal distances along the two curves.

We experienced great difficulty from the ice breaking when it was clamped or when it was struck to set it in vibration, but by continued trials we succeeded in obtaining two well-defined curves. The height of the vibrations was about one-third of a millimeter. It is not certain that the ice always attained its proper pitch.

The results are expressed in the following formula:

$$E = \frac{n^2 l^4 s}{(\cdot 28)^2 r^2}$$

in which l= length of the bar, r= the radius, s= specific gravity and n= the number of transverse vibrations per second.

Experiment I.—Jan. 29, 1885.

$l = 33{\cdot}$ cm. $r = {\cdot}77$ cm. $s = {\cdot}886$ $n = 54{\cdot}15$

$\therefore$ $E = 66 \times 10^9$

Experiment II.—Jan. 31, 1885.

$l = 35{\cdot}$ cm $r = {\cdot}90$ cm $s = {\cdot}886$ $n = 51{\cdot}4$

$\therefore$ $E = 55 \times 10^9$.

Transverse Deflection.

We next went to a neighboring pond and sawed rectangular beams of ice and made measurements upon their elasticity at the pond. Two boards about 20 cm. wide and 60 cm. long were laid upon the ice. Two half cylinders of wood were placed upon these to form the supports for the beams. The cathetometer rested upon a board 30 cm. square placed upon the ice. It read to fiftieths of a millimeter. After the experiments the part of the scale used was compared with a standard centimeter, made by Prof. W. A. Rogers of the Harvard Observatory, and each millimeter was found to be not more than $\cdot 02^{mm}$ in error, so the readings were not corrected. A vertical rod with a needle at the top was inserted in a board 15 cm. square and served as an index. The index was placed on the middle of the beam and the weights were arranged symmetrically on each side.

The ice was 23 cm. thick, had no cracks or fissures and seemed to be free from air bubbles. There were about 3 cm. at the bottom which appeared to be of a later formation than the rest, it was therefore sawed off.

Care was taken to have all the apparatus below zero before the experiments began so as not to melt the ice. The wind was very light all day and did not shake the index. The results are given in tables I and II.

The difference in the modulus of the same bar with the same weight at different times may in part be due to slight variations in the positions of the weights. The index was simply placed on the beam and may have been jarred by putting on or taking off the weights, although as much care as possible was taken to avoid these errors. There did not seem to be a limit of perfect elasticity to any of the beams we used, but all gradually bent under their own weight. The readings were taken before, during and after the weights were on. The downward deflection is used in calculating E′ and the return deflection E.

The formula used was obtained in the following manner:

Let P = weight divided in halves placed equidistant from the center of the beam, a = distance between the weights, l = length of span, wl = weight of the beam. Take the origin at

the centre of the curve. Then taking the moments about any section between one of the weights and the nearest support the elastic curve $E\frac{d^2y}{dx^2} = f(x)$ becomes

$$E\frac{d^2y}{dx^2} = -\left(\frac{P+wl}{2}\right)\left(\frac{l}{2}-x\right)+w\left(\frac{l}{2}-x\right)\left(\frac{\frac{l}{2}-x}{2}\right)$$

$$= -\frac{P}{2}\left(\frac{l}{2}-x\right)-\frac{w}{2}\left(\frac{l^2}{4}-x^2\right)$$

$$E\frac{dy}{dx} = -\frac{P}{2}\left(\frac{lx}{2}-\frac{x^2}{2}\right)-\frac{w}{2}\left(\frac{l^2x}{4}-\frac{x^3}{3}\right)+C$$

but $C=0$

$$Ey = -\frac{P}{2}\left(\frac{lx^2}{4}-\frac{x^3}{6}\right)-\frac{w}{2}\left(\frac{l^2x^2}{8}-\frac{x^4}{12}\right)+B$$

but $B=0$

limits $x=0$, $x=\frac{l}{2}$

$$Es = \frac{l^3}{4bd^3}(P+\tfrac{5}{8}W) \qquad \text{since } I=\frac{1}{12}bd^3$$

and $W=wl$.

s = the deflection at the centre if the weight was there.

limits $x=\frac{\alpha}{2}$ $x=\frac{l}{2}$

$$Es' = \frac{l^3}{4bd^3}(P+\tfrac{5}{8}W)-\frac{P}{4bd^3}\left(\frac{\alpha^2}{2}(3l-\alpha)\right)-\frac{w}{4bd^3}\left(\frac{\alpha^2}{8}(6l^2-\alpha^2)\right)$$

s' = the deflection at $x=\frac{\alpha}{2}$ when the weight is at the center.

The weight of the beam was acting all the time so that we only measured the deflection due to the weight P. Therefore the part containing W in the preceding formula will disappear. By the principle of reciprocal relations a weight at a distance from the centre $x=\frac{\alpha}{2}$ will produce the same deflection at the centre as the same weight placed at the center would produce at $x=\frac{\alpha}{2}$. If the weight had been at the centre we should have

$$E=\frac{Pl^3}{4bd^3s}$$

but we have seen that

$$s=\frac{s'l^3}{l^3-\frac{\alpha^2}{2}(3l-\alpha)}$$

$$\therefore E=\frac{P}{4bd^3s'}\left(l^3-\frac{\alpha^2}{2}(3l-\alpha).\right)$$

At another time we went where the old ice had been cut and a new crop about 5 cm. thick had formed. It was perfectly limpid and free from air bubbles. We sawed out half a dozen bars and conveyed them to the laboratory to make more careful measurements. The cathetometer rested on the stone steps of the laboratory. The same kind of supports was used as before. The index consisted of a needle run through a piece of cork which was pasted on the ice and could not be jarred. A similar index was placed upon the supports to see if they gave way under the load. It was found that they were firm and did not vary. All the apparatus was placed out in the air long enough to acquire its temperature before the experiments began.

The bars were smaller than the former ones and had a limit of perfect elasticity. In two cases the limit was exceeded, then smaller weights were put on and the bar was again perfectly elastic. The density of this ice was greater than that of the ice used in former experiments. It therefore appears that ice has a limit of perfect elasticity if small bars are used, but that large beams, although elastic to a certain extent, gradually bend under their own weight. The results are given in tables III and IV.

The symbols in the tables are:

L = length of the span,
T = temperature of the ice,
Δ = density of the ice,
b = breadth of the beam,
d = depth of the beam,
P = weight applied,
ϑ' = deflection of the beam from zero under a given load,
ϑ = the rise of the beam when the load is removed,
ε' = modulus of elasticity using ϑ',
ε = modulus of elasticity using ϑ,
α = distance between the weights.

The measurements are made in the C. G. S. system of units. The temperature is given in Centigrade degrees.

The values of ε and ε' are given in absolute measure.

I. February 12, 1885.

Bar.	L	a	T	Δ	b	d	P	ϑ'	ϑ	E	E′
A	118·	30	−10·0	·886	22·6	6·2	10,000	·016	·012	57×10^9	41×10^9

II. February 13, 1885.

Bar.	L	*a*	T	Δ	*b*	*d*	P	ϑ'	ϑ	E	E′
B	148	30	−3·0	·886	10·0	11·0	14,000	·0285	·014	56×10^9	26×10^9
C	205	"	"	"	10·0	8·7	6,000	·046	·035	53×10^9	41×10^9
"	"	"	"	"	"	"	"	·0404	·0302	62 "	46 "
"	"	"	"	"	"	"	8,000	·0495	·0423	59 "	50 "
"	"	"	"	"	"	"	10,000	·0704	·0494	63 "	44 "
"	"	"	"	"	"	"	12,000	·0705	·0535	70 "	53 "
"	"	"	"	"	"	"	10,000	·0708	·049	63 "	44 "
"	"	"	"	"	"	"	"	·055	·046	68 "	56 "
"	"	"	"	"	"	"	14,000	·085	·076	57 "	51 "
"	"	"	"	"	"	"	"	·100	·075	58 "	44 "
"	"	"	"	"	"	"	10,000	·054	·040	78 "	58 "
"	"	"	"	"	8·7	10·0	10,000	·049	·0344	68 "	48 "
"	"	"	"	"	"	"	14,000	·0568	·049	67 "	58 "
"	"	"	"	"	"	"	16.000	·0599	·0519	73 "	63 "
D	212	"	"	"	17 5	6·7	10,000	·155	·054	80 "	28 "
"	"	"	"	"	"	"	"	·0998	·0578	75 "	43 "
E	213	"	"	"	17·5	7·8	10,000	·100	·036	77 "	28 "
"	"	"	"	"	"	"	14,000	·121	·065	60 "	32 "
"	"	"	"	"	"	"	18,000	·155	·092	54 "	32 "
		"		Average						65×10^9	

III. February 19, 1885.

Bar.	L	*a*	T	Δ	*b*	*d*	P	ϑ'	ϑ	E	E′
H	107	20	−7·0	·920	4·5	6·6	4,000	·010	·010	88×10^9	88×10^9
"	"	"	"	"	"	"	6,000	·022	·022	60 "	60 "
"	"	"	"	"	"	"	10,000	·039	·039	57 "	57 "
"	"	"	"	"	"	"	16,000	·059	·059	60 "	60 "
"	"	"	"	"	"	"	25,459	·129	·069	81 "	44 "
"	"	"	"	"	6·6	4·5	10,000	·060	·060	79 "	79 "
"	"	"	"	"	"	"	25,459*	broke			"
I	94	"	"	"	6·6	4·5	22,730*	"			"
K	54	"	"	"	4·5	6·6	48,000*	"			"
				Average						71×10^9	

* Weight required to break the bar.

IV. February 20, 1885.

Bar.	L	*a*	T	Δ	*b*	*d*	P	ϑ'	ϑ	E	E′
M	131	20	−5·0	·920	5·0	6·8	10,000	·035	·035	97×10^9	97×10^9
"	"	"	"	"	"	"	"	·031	·031	109 "	109 "
"	"	"	"	"	"	"	14,000	·059	·059	80 "	80 "
"	"	"	"	"	"	"	24,543	·135	·088	95 "	62 "
"	"	"	"	"	"	"	25,000*	broke			
N	"	"	"	"	6·8	5·0	10,000	·090	·058	108×10^9	70×10^9
"	"	"	"	"	"	"	4,000	·028	·028	90 "	90 "
				Average						96 "	

* Weight required to break the bar.

Longitudinal Vibrations.

Before using bar M table IV we compared its note with that of a pitch pipe which had been graduated by a siren.

The ice gave three-tenths of a semitone of C sharp.

American Pitch.

Pitch Pipe C,	67·93	135·9	271·7	543·5	1087
C♯,	71·97	143·9	287·9	575·8	1152

ε = modulus of elasticity,
n = number of longitudinal vibrations per second,
l = length of bar,
Δ = density of bar,
$n = 1107.$ $l = 138.$ $\Delta = \cdot 920.$
$\therefore \varepsilon = 4l^2n^2\Delta = 86 \times 10^9.$

Summation.

Average of table I	57×10^9
" " " II	65 "
" " " III	71 "
" " " IV	96 "
" " all the observations	72 "

We assign greater value to tables III and IV than to I and II.

Average of tables III and IV	84×10^9
" " transverse vibrations	61 "
" " longitudinal "	86 "

Velocity of Sound in Ice.

$$v = \sqrt{\frac{\varepsilon}{\Delta}} = \sqrt{\frac{84 \times 10^9}{\cdot 920}} = 290{,}000 \text{ cm. per sec.} = 2900 \text{ m. per sec.}$$

or about nine times the velocity of sound in air.

Jefferson Physical Laboratory.

ART. XLV.—*Contributions from the Agricultural Experiment Station of the University of Wisconsin. Digestion Experiments;* by H. P. ARMSBY.

The methods of cattle-feeding worked out by the scientific experiments of the last twenty years require, as their basis, a knowledge of the average composition and digestibility of the fodders in common use. Thanks to the labors of American experiment stations, we have now a very fair knowledge of the composition of American feeding-stuffs; but for all estimates of their digestibility we have been obliged to take the results of

experiments on fodders grown in foreign countries, no determinations of the digestibility of any of our fodders having been reported. The following determinations of the digestibility of clover hay, malt-sprouts and cotton-seed meal by sheep are therefore presented as a contribution to our knowledge of the digestibility of American fodders:

Fodders.—The hay was first-crop red clover hay, of good quality, and nearly free from admixture of other vegetation. The malt-sprouts and cotton-seed meal were also of excellent quality, as was evident from their appearance and was confirmed by the results of chemical analysis.

Conduct of experiments.—Two grade Cotswold wethers, about three years old and weighing about 87 pounds each, were used for the experiments. The animals stood in stanchions, each in a separate stall specially built for the purpose. They were fed from zinc-lined feed boxes, which could be removed to be filled, and which were surmounted by a funnel-shaped structure of boards, which effectually prevented any scattering of the fodder. Each day's fodder was weighed out separately for from six to ten days in advance, the hay in cloth bags, the bye-fodder in glass fruit jars, and samples were taken at the same time for the determination of moisture or for complete analysis. The dung was collected in rubber-lined cloth bags (*Kothbeutel*), attached to the hind quarters of the animals by means of a light harness. The bags were emptied every twenty-four hours and the dung weighed.

A sample of about 100 grams of the fresh dung of each animal was at once taken and dried in a water bath. When sufficiently dry, it was allowed to stand loosely covered for about twelve hours, then weighed, rapidly ground, and preserved in a tightly closed glass jar. The percentage of water in the air-dry dung was subsequently determined, thus affording data for calculating the daily excretion of dry matter by each animal on every day of the experiments. At the close of each period, the samples of air-dry dung were mixed to form an analysis sample in such proportions that the quantity of dry matter from each day's dung contained in the mixture was proportional to the amount of dry matter excreted by the animal in question on that day.

As is well known, it is necessary in digestion trials to precede the actual experiment by a preliminary feeding in order to remove from the digestive organs remnants of previous fodder. In these experiments the preliminary feeding and the actual trial each lasted six days, in most cases. Throughout the experiments two grams of air-dry salt per day and head were given.

Sampling.—Since the value of a digestion experiment is largely dependent upon the correct sampling of fodders and dung, particular attention was paid to this point.

Each day's dung was sampled by spreading it out in a shallow tray and taking small portions from different parts of the tray until the desired amount was obtained.

The malt-sprouts and cotton-seed meal were sampled at the time of weighing out for feeding. The amount required for the last four days of the preliminary feeding and the six days of the actual experiment was weighed out at one time, each day's feed separately. As each one of these twenty portions was weighed out, a small amount was laid aside, and the mixture of these small portions constituted the analysis sample.

Substantially the same method of sampling was applied to the hay, but as it was desired to ascertain by these trials the average composition and digestibility of a considerable quantity of hay, the process was somewhat more elaborate.

The clover hay, to the amount of about three and one-half tons, was run through a power feed cutter, using nominally a half inch cut, although most of the hay was not actually cut as fine as that. The cut hay was spread out on a tight floor and thoroughly mixed, being handled entirely with shovels to prevent, as far as possible, the sifting to the bottom of the finer portions. It was then spread out about two feet deep in an approximately rectangular form upon a tight floor. Beginning near the diagonally opposite corners, two trenches, each about a foot wide, were dug into the mass parallel to the longest side of the rectangle, care being taken to secure whatever dust had sifted through to the floor. (Very little dust was found.) Two samples of about 500 pounds each were thus secured and stored separately in bins, and a digestion experiment was made with each sample.

In weighing out the hay for the experiments, a quantity more than sufficient was spread out upon a tight floor and cloth bags were filled by taking about two shovelfuls each, from different parts of the mass, while at the same time an analysis sample was taken in the way above described for the other fodders.

In the experiments with hay alone the fodder for the preliminary feeding and the actual experiment was weighed out at different times, so that we have two analyses of each of the 500 pound samples mentioned above. In the subjoined table these are numbered 1, 2, 3 and 4, and their close agreement attests the accuracy of the sampling.

Composition of Fodders.—Water Free.

No.		Ash.	Albuminoids.	"Amides."	Crude Fiber.	N. free Extract.	Fat.
1	Clover Hay -----	5·11	13·49		32·34	47·19	1·87
2	Clover Hay -----	4·99	10·71	2·31	32·99	47·24	1·76
3	Clover Hay -----	4·59	13·73		32·24	47·32	2·12
4	Clover Hay -----	4·85	10·71	2·90	32·88	46·89	1 77
5	Malt Sprouts ----	4·26	16·40	7·46	13·63	56·79	1·46
10	Cotton-seed Meal	7·01	43·01	4·60	3·00	27·83	14·55

Analytical Methods.—Water was determined by drying two grams at 110° C. in a current of dried illuminating gas, ash by burning at a low temperature and deducting CO_2 and char, fat by extraction of the dry substance with dry sulphuric ether, crude-fiber substantially by the modified Weende method of Wattenberg.* Total nitrogen was determined by combustion with the mixture of slaked lime and sodium carbonate recommended by Johnson and Jenkins.† Protein signifies nitrogen ×6·25. "Amides" (more properly non-albuminoid nitrogenous matters) were determined by Stutzer's method,‡ the soluble nitrogen found by that method being multiplied by 6·25. Albuminoids equal protein minus "amides." Nitrogen-free extract is by difference.

Period I.

During the first period, each sheep received per day in two feeds 700 grams of hay from one of the 500 pound samples previously mentioned, with water *ad libitum* twice per day. This amount of hay was eaten clean. The analyses above show the composition of the hay used for the preliminary feeding (No. 1) and the actual experiment (No. 2). As weighed out it contained:

No. 1, 83·87 per cent. of dry matter.
No. 2, 83·59 " " "

The water-free dung had the following composition:

	Ash. Per cent.	Protein. Per cent.	Crude Fiber. Per cent.	Nitrogen-free extract. Per cent.	Fat. Per cent.
Sheep 1 -----------	6·71	14·38	35·19	41·38	2·72
Sheep 2 -----------	6·57	14·00	35·31	41·51	2·23

The weights of fresh dung and of dry matter excreted, and of water drunk were as follows:

* Jour. f. Landw., xxviii, 273.
† Am. Chem. Jour., i, 77.
‡ Jour. f. Landw., xxviii, 103, and xxix, 473.

	Sheep 1.			Sheep 2.		
	Fresh dung. Grms.	Water-free dung. Grms.	Water drunk. Grms.	Fresh dung. Grms.	Water-free dung. Grms.	Water drunk. Grms.
Nov. 11	611·4	284·4	?	548·7	247·4	?
" 12	613·3	283·3	0	575·4	265·6	0
" 13	683·2	317·8	865	609·0	280·0	1630
" 14	555·7	263·2	893	622·6	[226·4]	1077
" 15	630·5	303·5	312	849·5	367·2	298
" 16	569·3	276·6	0	636.3	269·0	198
Average	610·6	288·1	414	640·3	285·8†	641
Correction*		0·5			0·5	
		288·6			286·3	

* For dung adhering to bags.

† Excluding Nov. 14th.

In the following table are calculated from these data the average amount of each ingredient of the hay eaten, excreted and digested per day:

	Dry matter.	Organic matter.	Protein.	Albuminoids.	Crude fiber.	Nitrogen-free extr't.	Fat.
Sheep 1.	Grms.	Grms.	Grms.	Grms.	Grms.	Grms.	Grms.
Fed, 700 grms. hay	596·1	556·6	77·7	62·8	191·5	276·7	10·7
Excreted, 610·6 grms. dung	288·6	269·2	40·4	40·4	101·5	119·4	7·9
Digested	297·5	287·4	37·3	22·4	90·0	157·3	2·8
Per cent digested	**50·8**	**51·6**	**48·0**	**35·7**	**47·1**	**56·8**	**26·2**
Sheep 2.							
Fed, 700 grms. hay	586·1	556·6	77·7	62.8	191·5	276·7	10·7
Excreted, 640·3 grms. dung	286·3	267·5	41·2	41·2	101·1	118·8	6·4
Digested	299·8	289·1	36·5	21·6	90.4	157·9	4·3
Per cent digested	**51·1**	**51·9**	**47·0**	**34·4**	**47·2**	**57·1**	**40·2**

In these computations the average of analyses 1 and 2 is assumed to represent the composition of the hay. The "Amides," being soluble in water, are assumed to be wholly digestible.

Period II.

In the second period, Sheep 1 received 700 grams and Sheep 2 but 650 grams of hay, each in two feeds per day, from the second of the two 500 pound samples. (Analyses No. 3 and No. 4.) Here follow the further data for this period.

Dry matter of hay.

No. 3, 84·59 per cent.
No. 4, 84·13 "

Composition of Dung.—Water free.

	Ash.	Protein. (N×6·25)	Crude Fiber.	Nitrogen free extract.	Fat.
	Per ct.	Per ct.	Per ct.	Per ct.	Per ct.
Sheep 1	6·71	13·99	35·70	41·24	2·36
Sheep 2	6·47	14·04	35·65	41·68	2·16

Daily Excretion.

	Sheep 1.			Sheep 2.		
	Fresh dung.	Water-free dung.	Water drunk.	Fresh dung.	Water-free dung.	Water drunk.
	Grms.	Grms.	Grms.	Grms.	Grms.	Grms.
Nov. 23	607·9	294·2	695	508·6	244·0	978
" 25	651·8	300·8	921	589·8	279·0	595
" 26	618·6	283·2	113	529·3	245·4	14
" 27	554·1	253·0	0	480·8	234·4	0
" 28	639·1	301·3	680	565·7	266·7	1474
Average	614·3	286·5	483	534·8	253·9	612
Correction		0·5			0·5	
		287·0			254·4	

Digestibility.

	Dry matter.	Organic matter.	Protein.	Albuminoids.	Crude fiber.	Nitrogen-free extr't.	Fat.
Sheep 1.	Grms.	Grms.	Grms.	Grms.	Grms.	Grms.	Grms.
Fed, 700 grms. hay	591·2	563·3	80·8	63·3	192·5	278·5	11.5
Excreted, 614·3 grms. dung	287·0	267·7	40·2	40·2	102·4	118·3	6·8
Digested	304·2	295·6	40·6	23·1	90·1	160·2	4·7
Per cent digested	**51·5**	**52·5**	**50·2**	**36·5**	**46·8**	**57·5**	**40·9**
Sheep 2.							
Fed, 650 grms. hay	549·0	523·1	75·0	58·8	178·8	258·6	10·7
Excreted, 534·8 grms. dung	254·4	237·9	35·7	35·7	90·7	106·0	5·5
Digested	294·6	285·2	39·3	23·1	88·1	152·6	5·2
Per cent digested	**53·7**	**54·5**	**52·4**	**39·3**	**49·3**	**59·0**	**48·6**

As in period I, the average of the two analyses of the hay is made the basis of the computation.

In the following table are brought together for more convenient comparison the results of periods I and II.

Percentage Digestibility of Clover Hay.

	Dry matter.	Organic matter.	Protein.	Albuminoids.	Crude fiber.	Nitrogen-free extract.	Fat.
Sheep 1.	Per cent.	Per cent.	Per cent.	Per cent.	Per cent.	Per cent.	Per cent.
Period I	50·8	51·6	48·0	35·7	47·1	56·8	26·2
Period II	51·5	52·5	50·2	36·5	46·8	57·5	40·9
Average	51·2	52·1	49·1	36·1	47·0	57·2	40·9*
Sheep 2.							
Period I	51·1	51·9	47·0	34·4	47·2	57·1	40·2
Period II	53·7	54·5	52·4	39·3	49·3	59·0	48·6
Average	52·4	53·2	49·7	36·9	48·3	58·1	44·4
Average of all	51·8	52·7	49·4	36·5	47·7	57·7	42·7*

* Excluding the result on sheep 1 in period I as probably erroneous.

Period III.

In a third period, the digestibility of malt sprouts was the subject of experiment, the sprouts being fed with the clover hay already experimented upon. Unfortunately, Sheep No. 2 had to be excluded from this experiment on account of a sore foot in consequence of which he ate poorly. Sheep No. 1 received per day 600 grams of the clover hay and 175 grams of malt sprouts. The latter were soaked in hot water and fed while still warm, the whole amount, together with half the hay, being fed at night and the remainder of the hay in the morning.

The preliminary feeding in this period was continued for nine days, but the analysis samples represent the material fed during the last four days of the preliminary feeding and the six days of the actual experiment.

In this and the subsequent period the average of analyses 1, 2, 3 and 4 is taken to represent the composition of the dry matter of the hay. Its digestibility is assumed to be the average of that found in Periods I and II for the animal under consideration.

Dry matter of Fodders.

Hay (No. 6), 83·49 per cent.
Malt Sprouts, (No. 5), 88·03 "

Composition of Dung.—Water free.

	Ash. Per cent.	Protein. Per cent.	Crude fiber. Per cent.	Nitrogen-free extract. Per cent.	Fat. Per cent.
Sheep 1	6·28	14·07	34·09	43·70	1·86

Daily Excretion.

	Sheep 1.		
	Fresh dung. Grms.	Water-free dung. Grms.	Water drunk. Grms.
Dec. 10	604·0	276·6	1120
" 11	802·5	356·5	624
" 12	732·9	298·6	0
" 13	626·8	281·1	1332
" 14	697·8	288·7	85
" 15	622·6	266·5	354
Average	681·1	294·7	586
Correction		0·5	
		295·2	

Digestibility.

	Dry matter.	Organic matter.	Protein.	Albuminoids.	Crude fiber.	Nitrogen-free extr't.	Fat.
	Grms.	Grms.	Grms.	Grms.	Grms.	Grms.	Grms.
Fed, 600 grms. hay	500·9	476·4	67·4	53·6	163·3	236·3	9·4
Fed, 175 grms. malt sprouts	154·1	147·5	36·8	25·3	21·0	87·5	2·2
Total	655·0	623·9	104·2	78·9	184·3	323·8	11·6
Excreted, 681·1 grms. dung	295·2	276·6	41·5	41·5	100·6	129·0	5·5
Digested, total	359·8	347·3	62·7	37·4	83·7	194·8	6·1
Digested from hay	256·4	248·2	33·2	19·4	76·8	135·2	3·8
Digested from malt sprouts	103·4	99·1	29·5	18·0	6·9	59·6	2·3
Per cent digested	**67·1**	**67·2**	**80·2**	**71·2**	**32·9**	**68·1**	**104·6**

Period IV.

The preliminary feeding continued six days. Each animal received 700 grams of hay and 175 grams of cotton-seed meal. The meal was given dry, sprinkled over the night feed of hay, and the fodder was always eaten clean. For sixteen days previous to the preliminary feeding the sheep had been fed the same fodders, and in approximately the same amounts, as in the experiment. The analysis samples of the fodders represent, as in Period III, the last four days of the preliminary feeding and the six days of the actual experiment.

Dry matter of fodders.

Hay (No. 9),	84·09 per cent.
Cotton-seed meal (No. 10.),	92·41 "

Composition of Dung.—Water free.

	Ash.	Protein.	Crude fiber.	Nitrogen-free extract.	Fat.
	Per cent.	Per cent.	Per cent.	Per cent.	Per cent.
Sheep 1	6·44	15·31	34·57	41·87	1·81
Sheep 2	6·35	15·72	33·98	42·15	1·80

Daily Excretion.

	Sheep 1.			Sheep 2.		
	Fresh dung.	Water-free dung.	Water drunk.	Fresh dung.	Water-free dung.	Water drunk.
	Grms.	Grms.	Grms.	Grms.	Grms.	Grms.
January 8	740·7	297·0	1417	894·1	369·7	765
" 9	1010·1	392·8	751	750·5	307·0	113
" 10	805·2	298·0	1176	759·7	295·6	1588
" 11	792·4	292·6	1119	707·1	283·5	1375
" 12	852·3	342·0	397	921·5	348·7	411
" 13	686·8	273·9	1106	699·6	264·1	978
Average		316·1	994		311·4	872
Correction		0·5			0·5	
		316·6			311·9	

Digestibility.

	Dry matter.	Organic matter.	Protein.	Albuminoids.	Crude fiber.	Nitrogen-free extract.	Fat.
Sheep 1.	Grms	Grms	Grms	Grms	Grms	Grms	Grms
Fed, 700 grms. hay	588·6	559 8	79·2	63·0	191·9	277·6	11·1
Fed, 175 grms. cotton-seed meal	161·7	150·4	77·0	69·5	4·9	45·0	23·5
Fed, total	750·3	710·2	156·2	132·5	196·8	322·6	34·6
Excreted, 814·6 grms. dung	316·6	296·2	48·5	48·5	109·4	132·6	5·7
Digested, total	433·7	414·0	107·7	84·0	87·4	190·0	28 9
Digested from hay	301·4	291·7	39·0	22·7	90·2	158·8	4·5
Digested from cotten-seed meal	132·3	122·3	68·7	61·3	?	31·2	24·4
Per cent digested	**81·8**	**81·3**	**89·2**	**88·2**	**?**	**69.3**	**103·9**
Sheep 2.							
Fed, total	750·3	710·2	156·2	132·5	196·8	322·6	34·6
Excreted, 788·8 grms. dung	311·9	292·1	49·0	49·0	106·0	131·5	5·6
Digested, total	438·4	418·1	107 2	83·5	90·8	191·1	29·0
Digested from hay	308·4	297·8	39·4	22·9	92·7	161·3	4·9
Digested from cotton-seed meal	130·0	120·3	67·8	60·6	?	29·8	24·1
Per cent. digested	**80·4**	**80·0**	**88·1**	**87·2**	**?**	**66·2**	**102·5**

It is of some interest to compare these results with those obtained by Wolff in some recent experiments,* also on sheep:

Digestibility of Cotton Seed Meal.

	Wolff's experiment.	Average of these experiments.
Dry matter	74·0	81·1
Organic matter	80·4	80·7
Protein	84·7	88·7
Crude fiber	----	----
Nitrogen-free extract	83·7	67·8
Fat	87·6	----

In the following table the amounts of digestible matters present in the three fodders have been calculated in per cents of the whole fodder:

	Percentage Composition.							Digestible.			
	Water.	Ash.	Protein.	Albuminoids.	Crude fiber.	Nitrogen-free extract.	Fat.	Protein. (N×6·25).	Albuminoids.	Carbhydrates.†	Fat.
Clover hay, average of four analyses	16·07	4·10	11·30	8·99	27·37	39·58	1·58	5·58	3·27	35·80	0·67
Malt sprouts	11·97	3·75	21·00	14·44	11·99	50·00	1·29	16·86	10·27	38·35	1·29
Cotton-seed meal	7·59	6·48	44·00	39·59	2·77	25·72	13·44	39·07	34·72	17·67	13·44

* Landwirthschaftliche Versuchs-Stationen, xxvii, 215.

† Digestible crude fiber and nitrogen-free extract.

Probable Errors of the Results.

It is a matter of some importance to know to what amount of error the results obtained in these experiments are subject. They obviously are not susceptible to a strict mathematical treatment according to the theory of probabilities, such as might be applied to astronomical or physical observations. At the same time it appears possible, by making what seem reasonable assumptions upon certain points, to fairly approximate to the probable errors of the results. In the following paragraphs this has been attempted:

Experiments with hay alone.—a. Errors in weighing fodder and dung. The hay was weighed out upon a balance sensitive to 0·1 gram. As, however, the conditions were not always favorable to extreme care in weighing we will assume 0·1 gram as the probable error of a single weighing. Then, since the weight of the hay was obtained by subtracting the weight of the empty from that of the filled bag, the probable error in the weight of hay for one day is $\pm\sqrt{0{\cdot}1^2+0{\cdot}1^2}=\pm 0{\cdot}14$ grms. In like manner, the weight of fresh dung daily excreted is subject to a probable error of $\pm$ 0·14 grams. As, however, the experiment was continued for six days, the probable error of the *average for one day* is in each case $\pm$ 0·14 $\div\sqrt{6}=0{\cdot}058$ grams. This quantity, expressed as per centage of the average amount fed or excreted (700 grams and 622 grams), equals 0·008 per cent and 0·009 per cent respectively, and is obviously so small that for the purposes of this calculation it may be neglected.

b. Analytical errors. In addition to the errors arising in the weighing of fodder and dung, the unavoidable errors of analysis must be taken into account. These can be computed with some degree of accuracy for the determinations of dry matter, nitrogen and crude fiber. For the organic matter and fat the data are less complete, and owing to the less importance which attaches to these determinations, the computations have not been attempted. Nitrogen-free extract has also been excluded from the computation, because, being determined by difference, all the errors of the other determinations are included in it.

The amount of dry matter fed in Periods I and II is deduced from the average of analyses Nos. 1 and 2 and Nos. 3 and 4 respectively, or, each determination being in duplicate, from the average of four single analyses.

Taking this small number as the basis of a calculation of probable error we obtain the following results:

PERIOD I.

		v.	vv.
	83·86 per cent.	+0·125	0·0156
	83·89 "	+0·155	0·0240
	83·60 "	−0·135	0·0182
	83·59 "	−0·145	0·0210
Sum,	334·94	0	0·0789
Average,	83·735 "		

Probable error of one determination 0·110 per cent.

PERIOD II.

	84·65 per cent.	+0·2925	0·085556
	84·52 "	+0·1625	0·026406
	84·13 "	−0 2275	0·051756
	84·13 "	−0·2275	0·051756
Sum,	337·43	0	0·215475
Average,	84·3575 "		

Probable error of one determination 0·186 per cent.

Subsequently, twelve determinations of dry matter were made upon another fodder (coarse wheat bran) by the same method.

These twelve determinations gave as the probable error of a single determination of dry matter by this method ± 0·12 per cent, a result agreeing well with the smaller of the two errors computed above.

If, then, in our computations, we assume ± 0·12 per cent to represent the probable error of one determination of dry matter, we shall at least not over-estimate it.

For a computation of the probable error of the nitrogen and crude fiber estimations in the fodder we have eight determinations each, made on samples agreeing so closely in composition that they may fairly be assumed to have been identical. On this assumption, we get the following results:

Nitrogen.			Crude fiber.		
	v.	vv.		v.	vv
2·10	−0·05	0·0025	32·92	−0·65	0·4225
2·20	+0·05	0·0025	32·95	−0·62	0·3844
2·07	−0·08	0·0064	33·55	−0·02	0·0004
2·09	−0·06	0·0036	33·64	+0·07	0·0049
2·21	+0·06	0·0036	33·71	+0·14	0·0196
2·19	+0·04	0·0016	33·44	−0·13	0·0169
2·21	+0·06	0·0036	33·96	+0.39	0·1521
2·13	−0·02	0·0004	34·36	+0·79	0·6241
17·20	0	0·0242	268·56	0	1·6249
2·15			33·57		
Probable error of 1 determination ±0·040.			Probable error of 1 determination ±0·325.		

Twelve determinations each of nitrogen and crude fiber on the sample of bran mentioned above gave the following results:

	Nitrogen.	Crude fiber.
Probable error of 1 determination...	0·052 per cent.	0·22 per cent.

These figures differ somewhat, but not very greatly, from those computed directly from the analyses in question, and serve to show that the latter include no gross errors.

The determinations of dry matter, protein and crude fiber in the dung were made in precisely the same manner as with the fodders. As only duplicate determinations were made on any one sample there are no sufficient data for a computation of probable errors, but there is no evident reason why they should differ essentially from those of the same determinations on fodders, and we shall assume that they do not.

From these data as to the probable errors of the percentages of dry matter, protein and crude fiber found by analysis, we proceed to compute, in grams, the probable errors of the amounts of each ingredient eaten and excreted. In doing this it must be remembered that the percentages of dry matter are to be calculated upon the amount of air-dry hay fed, or of fresh dung excreted, while the percentages of protein and crude fiber are to be reckoned upon the amount of *dry matter* fed, or excreted. We may, for convenience, first compute the probable errors on the basis of a single determination each to be as follows:

Probable Errors.—Single Determination.

	Average consumption. Grms.	Average excretion. Grms.
Fresh	700	622
Dry matter	588 ± 0·84	287 ± 0·75
Protein (N × 6·25)	78 ± 1·47	39 ± 0·72
Crude fiber	189 ± 1·91	99 ± 0·93

These probable errors have now to be reduced in accordance with the number of observations upon which the value of each quantity depends. These are as follows:

For dry matter, protein and crude fiber of fodder, four determinations; for protein and crude fiber of dung, two determinations. The value for dry matter excreted rests upon duplicate daily determinations, repeated for six days. The error as above computed, then, should be divided by $\sqrt{2}\times\sqrt{6}=3\cdot46$.

For the actual probable errors, then, we find the following amounts:

Probable Errors.

	Average consumption. Grms.	Average excretion. Grms.	Average digested. Grms.
Dry matter	588 ± 0·42	287 ± 0·22	301 ± 0·47
Protein (N × 6·25)	78 ± 0·74	39 ± 0·51	39 ± 0·90
Crude fiber	189 ± 0·96	99 ± 0·66	90 ± 1·17

By dividing the probable errors of the last column by the amounts of the corresponding ingredients fed, we obtain the percentage error, viz:

Dry matter	±0·08 per cent.
Protein	±1·15 "
Crude fiber	±0·62 "

That is, the percentages for digestibility as given on p. 360 are subject to these errors.

Experiments with bye-fodders.—In these experiments we have the additional errors arising in the weighing out and analysis of the bye-fodder.

a. Errors in weighing. The bye-fodders were weighed on the same balance as the hay, but were weighed directly, and are consequently subject to an error of only ± 0·1 gram for a single weighing. Both bye-fodders and hay were weighed out for ten days at a time instead of for six as in Periods I and II. Plainly, then, the error due to weighing will be less than in those periods and may be neglected.

b. Analytical errors. The analytical errors we may calculate upon the same basis as before, remembering, however, that the composition of the hay in these experiments is the average of eight determinations, except the dry matter, which is the average of but two (compare p. 358), while that of the bye-fodder is the average of only two.

The errors in the determination of the excretion would be practically the same in amount as before.

PROBABLE ERRORS.

Malt Sprouts.

	Dry matter. Grms.	Protein (N×6·25). Grms.	Crude fiber. Grms.
Hay fed	500±0·51	67±0·44	163±0·57
Malt sprouts fed	154±0·15	37±0·27	21±0·35
Total fed	654±	104±	184±
Excreted	295±0·22	42±0·51	101±0·66
Digested	359±0·97	62±	83±
Digested from hay	256±0·40	33±0·76	76±1·08
Digested from M. S.	103±0·70	29±1·05	7±1·43
Percentage error	±0·45 pr. ct.	±2·84 pr. ct.	±6·82 pr. ct.

Cotton-seed Meal.

Hay fed	589±0·59	79±0·52	192±0·68
C. S. M. fed	162±0·15	77±0·29	5±0·37
Total fed	751±	156±	197±
Excreted	314±0·22	49±0·51	109±0·66
Total digested	437±	107±	88±
Digested from hay	301±0·47	39±0·90	90±1·17
Digested from C. S. M.	136±0·80	68±1·19	−2±1·55
Percentage error	±0·49 pr. ct.	±1·55 pr. ct.	±31·01 pr. ct.

It thus appears that the digestion coëfficients for the bye-fodders are subject to a considerable analytical error, which, when expressed as above, of course varies in amount with the proportion of the ingredients in question which the bye-fodder contains. Thus the absolute probable error of the amount of crude fiber digested is very nearly the same in the malt sprouts as in the cotton-seed meal, but the very small percentage of fiber contained in the latter substance renders the percentage error much greater.

There is, however, another and more serious source of error in the determination of the digestibility of bye-fodders. G. Kühn* has recently shown that the digestibility of the same fodder by the same animal may vary at different times. He shows this to be true for hay alone, and also for a mixture of hay and bran. In these experiments the same phenomenon appears. Sheep No. 2 digested the hay decidedly better in Period II than in Period I, (compare p. 360), the differences being much larger than the probable errors of experiment, while Sheep No. 1 shows no such difference except as regards the protein and perhaps the fat. The variations of the single coëfficients from the mean of the two periods is:

Dry matter	1·3 per cent.
Protein	2·7 "
Crude fiber	1·1 "

There is no obvious reason why the digestibility of the hay may not have varied from the mean assumed for it in the experiments with bye-fodders. We have no measure of the probable amount of that variation, but it is reasonable to assume a *possible* variation at least as great as that observed on the hay alone. Then in the calculations on p. 363 the values of the amounts digested from the hay will be subject to a possible error from this cause of

	Malt sprout experiments.	C. S. M. experiments.
Dry matter	±6·50 grms.	±7·64 grms.
Protein	±1·81 "	±2·13 "
Crude fiber	±1·79 "	±2·11 "

Combining these with the probable analytical errors, we have the following for the *possible* errors. (We omit the calculation for the sake of brevity.)

Possible Errors.

	Malt sprouts.			Cotton-seed meal.		
	±			±		
Dry matter	6·54 grms.	= 4·25	per cent.	7·67 grms.	= 4·74	per cent.
Protein	2·09 "	= 5·66	"	2·44 "	= 3·17	"
Crude fiber	2·29 "	=10·91	"	2·62 "	=52·37	"

* Landw. Versuchs-Stationen, xxix, 1.

In view of these large possible errors, it is quite evident that the determinations of the digestibility of these three ingredients of the malt-sprouts and cotton-seed meal have little scientific value. This was, of course, sufficiently evident as regards the crude-fiber of the cotton-seed meal from the fact that an apparent negative digestibility was observed. Moreover, it is evident that the fat determinations are equally valueless, since an apparent digestibility of more than 100 per cent was observed in every case. We must conclude, then, that while, as shown on p. 366, the digestibility of the total ration was determined with reasonable accuracy, the computation of the digestibility of the bye-fodder involves so many possibilities of error that the results have very little value. Essentially the same conclusion was reached by Kühn in his paper already cited.

If we concede this, however, the further question arises, whether the results of the large number of digestion experiments made upon bye-fodders during the past twenty years deserve any greater degree of confidence. So far as the writer can see, this question must be answered in the negative. Both Kühn's experiments and those here reported were made with every precaution to ensure accuracy, and, so far as can be judged from the published accounts, are at least equal in this respect to the great majority of other experiments. Moreover, it has been assumed that there was no error of sampling and no loss of either fodder or excrement. In short the computed possible errors are due simply to errors of analysis and possible variations of digestibility and these we have endeavored not to over-estimate. The averages of a number of determinations which we find given in tables of the digestibility of fodders, have, of course, a certain practical value as approximations to the truth. They may properly be made the basis of the calculation of rations in practice, but neither they nor the single results upon any given fodder can properly enter into any scientific calculation of the nutritive effect of a ration.

ART. XLVI.—*Massive Safflorite;* by LEROY W. MCCAY.

ABOUT a year and a half ago I published, in Freiberg, Saxony, a pamphlet upon cobalt, nickel and iron pyrites.* In the first part of this little brochure I endeavored to show that the rhombic modification of speiskobalt, so carefully described by Sandberger and by him called spathiopyrite, is identical with the safflorite of Breithaupt. The arguments

*Beitrag zur Kenntniss der Kobalt, Nickel- und Eisenkiese, Freiberg, 1883.

advanced in support of the identity of the two minerals proved amply convincing, for, shortly after the appearance of the pamphlet, Sandberger, in a letter to the editors of the Jahrbuch,* distinctly admits his willingness to withdraw his name spathiopyrite and to substitute for the same the Breithaupt term safflorite.

In my article upon safflorite, however, I not only concluded, in accordance with Breithaupt's, Sandberger's and my own researches, that there was actually a *crystalline* rhombic modification of speiskobalt, but also that there was undoubtedly a *massive* rhombic modification of this species. Sandberger, now, although ready to admit the existence of the crystalline modification, i. e. safflorite, calls in question my right to use the term to cover the massive varieties. Why he should object to my using the words in the broad sense I am unable to discover. He further appears to doubt the accuracy of the statement which appears so often in Breithaupt's Paragenesis,† to the effect that speiskobalt and safflorite appear together, and suggests it as well to examine the specimens belonging to the Freiberg collection with the view of discovering what this safflorite really is. The specimens from Bieber, Schneeberg, Reinerzau and Wittichen which Sandberger had opportunity to examine exhibited no indications of the two minerals occurring together.

It is just possible that Sandberger may have misunderstood me respecting my reasons for inferring the existence of massive safflorite, and yet I am unable to see why, for, with one possible exception, my language on this point is perfectly clear. It is not intended that the word safflorite shall be used to designate *all* massive varieties of speiskobalt, as Sandberger seems to infer, but only to specify such as possess as high a gravity as 7·0. It is a well established fact that numbers of specimens of massive speiskobalt give specific gravities ranging from 6·9–7·3, that these specimens are invariably gray and that they are, as a general thing, rich in iron. The specific gravity of typical smaltine is now about 6·50, consequently these arsenides cannot be real smaltine, and, since the iron cannot occasion the high weight, there remains but one species under which to class them and this species is safflorite. We have a massive variety of the rhombic modification of the nickel arsenide and its high specific gravity is its exclusive determining mark; hence, nickel and cobalt being twin elements, the right of insisting upon the exisence of the corresponding cobalt compound is certainly just and proper. If the

* Neues Jahrbuch für Min., Geol. und Palæont., Jahrgang, 1884, vol. i, pp. 69–70.

† Die Paragenesis der Mineralien, pp. 222, 223.

existence of the massive variety of safflorite be deemed questionable, then the existence of the massive variety of rammelsbergite must be deemed questionable, for the proof in favor of the existence of the former is fully as convincing as that in favor of the existence of the latter. I feel sure that the majority of mineralogists will support me upon this point. Before it was fully settled that there was a rhombic modification of speiskobalt it was perfectly proper to question the propriety of regarding these heavy varieties as other than tesseral in system, but now that the existence of safflorite has been established on an incontrovertible basis no doubt can, I think, be raised as to the right of classing them under the rhombic form. Thus our classification would be complete for, just as we have with reference to nickel:

I. Chloanthite, tess., sp. gr. 6·50
II. Rammelsbergite, rhomb., sp. gr. 7·122
1. crystalline.
2. massive.

So likewise have we with reference to cobalt:

I. Smaltine, tess., sp. gr. 6·50
II. Safflorite, rhomb., sp. gr. 7·129
1. crystalline.
2. massive.

So much then for my reasons for insisting upon the existence of the massive variety.

While engaged in studying cobalt and nickel minerals I did not examine a massive variety of safflorite and my conclusions were all drawn from analyses made by others. After reading Sandberger's letter I wrote to Professor Weisbach in Freiberg, requesting him to send me for examination some specimens of speiskobalt which should, if possible, exhibit the occurrence of smaltine and massive safflorite together. Professor Weisbach, with his usual courtesy and amiability, responded immediately to my request, and forwarded to me several pieces of a massive, gray and very heavy specimen of cobalt arsenide. Upon two of these pieces there are perched a number of little tin-white crystals of smaltine perfectly distinct and well marked. The Schneeberg miners call the gray mineral schlackenkobalt and as such it was labeled.

The fracture is conchoidal, the structure proper finely granular and microcrystalline. Here and there little cavities are visible lined with microcrystals. The surfaces exhibit a faint shimmer and some pieces show a play of colors. In addition to the smaltine already mentioned there is present a small quantity of crystallized quartz.

The specific gravity was first taken with a number of pieces about the size of peas, no special care, however, being observed as to selection. I obtained:

1.	6·832
2.	6·839
3.	6·845

Although too high for smaltine the results were unsatisfactory. A careful examination, with a hand glass, of a large number of pieces, disclosed the presence of numerous tiny orifices. I therefore selected with the greatest care a sufficient quantity of what appeared to be the most homogeneous chips, and again made two determinations. I obtained:

1.	6·858
2.	6·859

In every case the pieces of mineral were thoroughly boiled in water.

These figures are also too low. All five, however, agree in a very remarkable manner with the specific gravity of a crystalline safflorite which was analyzed by Jaeckel* in Heintz's laboratory. The specific weight was taken by Rose, who found 6·840. Rose says the weight is low owing to the presence of porosities. Feeling assured that these porosities were the cause of the trouble in my case, I powdered a quantity of the schlackenkobalt, brought 5·2555 grams into a picnometer and, having filled the same about half full of water, placed it for one hour under the air pump, then for two hours on the boiling water bath and, finally, heated the water in the bottle over a free flame to boiling, care being taken to avoid any loss which might result from too violent ebullition. The heating was continued for several minutes. After the water had cooled to the temperature of the room the specific gravity of the mineral was again taken. In this case the result was most satisfactory, the figure 7·167 being obtained. Temperature of the water during the experiment 25·5° C. The mineral, then, is either rammelsbergite or safflorite. I next made a very careful chemical analysis with the following result:

Quantity for analysis 0·5 grm.

As	69·52
S	0·90
Co	18·36
Ni	not even a trace!
Fe	9·40
Cu	0·62
Bi	tr.
Insoluble	1·30
	100·10

* Rose's Krystallo-chemisches System.

The arsenic was estimated according to a method of my own which is fully described in the Chemical News, vol. xlviii, No. 1232, page 7. The cobalt was determined electrolytically.

After subtracting the insoluble residue, recalculating and dividing each percentage by the proper atomic weight we obtain:

As	70·36 ÷ 75 = 0·938	
S	0·90 ÷ 32 = 0·028	
Co	18·58 ÷ 59 = 0.314	·492
Ni		
Fe	9·51 ÷ 56 = 0·169	
Cu	0·62 ÷ 63 = 0·009	
Bi	tr.	
	99·97	

To form RS^2 14 atoms of R are necessary. Subtracting this amount from 492 we obtain:

$$478 : 938 = 1 : 1{\cdot}96 = 1 : 2$$

Hence the formula is:

$$\left.\begin{matrix} x\,(RS^2) \\ X(RAs^2) \end{matrix}\right\} \text{R=Co, Fe and Cu.}$$

My analysis of schlackenkobalt agrees in a most peculiar way with the analysis of a mineral from Schneeberg which was examined by Von Kobell* and called by him eisenkobaltkies. In order that a comparison can be readily made, I here place the two analyses along side of each other:

Von Kobell (Schneeberg). Sp. gr.=6·95 Crystallized.		McCay (Schneeberg). Sp. gr.=7·167 Massive.	
As	71·08	As	70·36
S	tr.	S	0.90
Fe	18·48	Co	18·58
Co	9·44	Fe	9.51
Ni	none	Ni	none
Cu	tr.	Cu	0·62
Bi	1·00	Bi	tr.
	100·00		99·97

It will be seen that the quantity of cobalt in the schlackenkobalt is identical with the amount of iron in the eisenkobaltkies and that the quantity of cobalt in the eisenkobaltkies is identical with the amount of iron in the schlackenkobalt. This is certainly most remarkable! Can it be the result of chance? I think not; I am inclined to believe that Von Kobell

* Von Kobell: Gründ. Min., 1838, S. 300.

made a mistake in writing down his figures—that he confounded the cobalt with the iron percentage and vice versa. The sum 100 indicates that the analysis was done by difference. Had it been made directly and had the sulphur and copper been carefully determined the chances are the agreement with my results would have been even closer.

It is a very interesting fact that the mineral analyzed by Von Kobell was crystalline. He says it was between tin-white and light steel-gray in color, and he calls attention to the fact the crystals were grouped in spheres and resembled, individually, thin, flat rhombohedrons. The mineral will be immediately recognized as Breithaupt's safflorite. It is exceedingly gratifying to find an analysis of a crystalline safflorite which agrees so well (although, I must confess, in a peculiar way) with one of the massive variety and the meaning is at once evident.

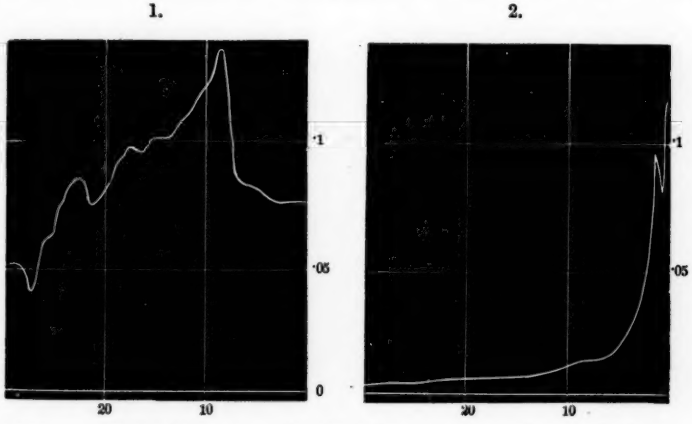
The specific gravity 7·167, together with the results of the chemical analysis, prove without a doubt that the heavy, gray and massive mineral sent me by Professor Weisbach and labeled schlackenkobalt is, indeed, safflorite, and the accompanying tin-white smaltine demonstrates conclusively that smaltine and safflorite do appear together and that too in precisely the manner indicated by Breithaupt in his Paragenesis. I trust, then, that this article will serve to overthrow any doubt which may exist in the minds of mineralogists concerning the certainty of the existence of a massive variety of safflorite and that my views as here set forth may atone for any equivocal statement or statements which may have inadvertently crept into my pamphlet.

John C. Green School of Science, Princeton, N. J., Jan. 20th, 1885.

ART. XLVII.—*Application of Photography to Electrical Measurements;* by JOHN TROWBRIDGE and HAMMOND VINTON HAYES.

IN the study of electromotive force and of voltaic cells it is often desirable to have long continued observations. The complete history of the action, for instance, of the Daniell cell with different strengths of solution extending over hours or days, if it could be presented to the eye as a curve, would be valuable to those who desire to know the behavior of such a cell while it is doing work under definite conditions. Such curve could be obtained by patient observation, but it would be unprofitable labor for one to spend his time in watching the excursions of a galvanometer needle, if the needle can be made to record its movements by any device.

The method we have used enables one to study the action of a cell at one's leisure, the apparatus running at night or during the day when one is occupied with other work. A beam of light from a gas flame passes through a vertical slit placed in front of the flame and is reflected from the concave mirror of a tangent galvanometer, of few turns of wire, through a horizontal slit in a dark box in which a sheet of sensitive paper is placed. By means of this arrangement of a vertical and a horizontal slit a small point of light is obtained. A stationary concave mirror is placed near the needle of the tangent galvanometer, so that the same beam of light may be reflected by both this mirror and the one attached to the galvanometer needle. The spot of light given by the stationary mirror serves to mark the zero point of the needle when no current is passing through the galvanometer. The photographic paper is placed in a slide which is lowered uniformly by the unwinding of a string from a little cylinder placed either upon the hour hand or the minute hand of a cheap eight-day clock. When the electrical current from the voltaic combination, which is being used, passes through the galvanometer its changes in strength for different times are indicated by the relations of the two lines drawn upon the sensitive paper. The line drawn by the light from the stationary mirror is a straight one, and serves for the abscissa



of times, while the perpendicular distances from the curve drawn by the mirror attached to the needle of the galvanometer to this axis of times give the ordinates of the curve drawn by the latter. Rapid printing paper was used and an ordinary gas flame gave a sufficiently strong spot of light to produce an actinic effect.

Fig. 1 represents the action of a modification of Trouvé's battery. During this experiment, which lasted for thirty minutes there were five ohms in the external circuit. The right hand portion of the diagram shows the strength of current when the circuit was made, and it will be observed that the battery was not at its best until ten or twelve minutes after making the circuit; from this maximum point the strength of the current gradually diminishes. Fig. 2 shows the action of the same battery with ten ohms external resistance. Under these conditions we find at the instant of making circuit a strong current which rapidly diminishes within the first five minutes to one-sixth of its first strength.

Knowing the distance of the galvanometer from the sensitive paper the strength of the current may be calculated by measuring the distance between the two lines at any instant and proceeding as with an ordinary galvanometer and scale.

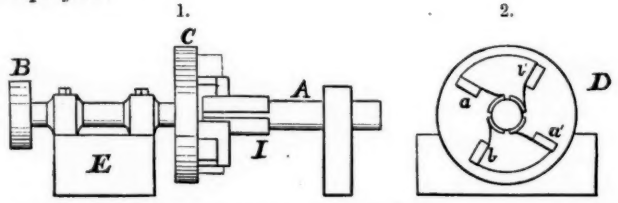
From a comparison of the two figures the electromotive force may be determined by Ohm's law, if the distance between the lines is measured at the instant the current is made. Then knowing the electromotive force, current, and external resistance, we can readily find the internal resistance. This resistance will be the liquid resistance of the cell only for the moment that the circuit is made, for afterward the variation in electromotive force due to polarization, and the change in resistance of the liquid due to electrolytic action will combine to cause changes. Since, however, the changes in electromotive force due to polarization are much more rapid in their action than the changes in battery resistance a very small error will be introduced if we compare points near each other on those parts of the curve in which the variation in current is greatest: during the small fraction of a minute that is taken the change in battery resistance will be infinitesimal and may be neglected.

We have selected these photographs as an example of the large variations that some batteries present and the consequent usefulness of some such way of studying their action. From measurements upon these photographic charts the variations in electromotive force and internal resistance can be studied by obtaining such charts under different conditions of external resistance. It is evident that the same photographic method can be employed to study the swing of the needle of a short coil galvanometer which indicates the gradual heating of a thermopile. In this way the conduction of heat along a bar could be studied.

Jefferson Physical Laboratory.

ART. XLVIII.—*On the production of alternating currents by means of a direct current dynamo-electric machine;* by JOHN TROWBRIDGE and HAMMOND VINTON HAYES.

IT is often desirable to transform a direct current into an alternating one for the purpose of obtaining electricity of high tension by means of a Ruhmkorff coil, for studying the effects of stratifications in vacuum tubes, or for employing alternating currents in the study of magnetism. The best way is undoubtedly to employ an alternating dynamo-electric machine, as has been done by Spottiswoode. When, however, only a direct current machine is available the following method can be employed:



The dynamo machine, if it is not a shunt wound machine, is shunted by a suitable resistance. We have employed for this purpose thin ribbon steel about 1·5 cm. broad and ·01 mm. in thickness. The remaining portion of the current from the machine is conducted to two brass or copper segments *a a'*, fig. 2. This current is led to the primary coil for, for instance of a Ruhmkorff coil from two other segments *b*, *b'*. These segments are fixed upon a cylindrical shaft A, fig. 1, which is stationary. A belt passing over the pulley B turns the wheel C upon the face D of which revolve four brushes which connect the adjoining segments. The brushes *a a*, *b b*, are made adjustable, the two adjoining brushes being electrically connected, and a small stream of water plays upon the segments of the commutator. The character of the spark produced by a Ruhmkorff coil which is marked by alternating currents has been studied by Spottiswoode. Without condensers in the secondary circuit a bright yellow glow spans the distance between the two terminals of the coil which partakes more of the character of a voltaic arc than of the ordinary discharge from a Ruhmkorff coil. The apparatus which we used produced three thousand reversals a minute. This rate was too rapid for the best effects with a Ruhmkorff coil. It enabled us, however, to study the musical note produced in the cores of the electro-magnet by rapid reversals of the current in the electro-magnet, and also the heating effects which have been so often studied.

Jefferson Physical Laboratory.

ART. XLIX. — *Topaz from Stoneham, Maine;* by F. W. CLARKE and J. S. DILLER.*

IN 1882, Mr. G. F. Kunz called attention to a new locality for topaz, discovered by Mr. N. H. Perry, of South Paris, Maine, in the neighboring town of Stoneham. The announcement aroused considerable interest among collectors of minerals, and somewhat later the locality became famous as a source of the very rare species herderite. In addition to topaz and herderite, the locality yields albite, apatite, autunite, biotite, beryl, columbite, damourite, fluorite, gahnite, garnet, muscovite, orthoclase, quartz, triplite, and zircon, together with other materials of obscure and doubtful character. This list of species was furnished by Mr. Perry, who also supplied us with material for investigation.

In the latter part of 1883, Mr. C. M. Bradbury† published an analysis of the Stoneham topaz, which, if correct, would show the mineral to be quite unlike any topaz hitherto known. His results were as follows, and make the proportion of fluorine half as high again as the generally accepted formula for topaz would require. The figures in parentheses are added to facilitate comparison with our own data:

Sp. Gr. 3·54

Al	27·14	(Al_2O_3, 51·26)
Si	14·64	(SiO_2, 21·37)
F	29·21	
O	28·56	
	99·55	

The peculiar interest attaching to these figures made a new analysis desirable; and accordingly the task was undertaken in the laboratory of the U. S. Geological Survey. Meanwhile Mr. Perry had called our attention to some apparently altered topaz; the crystals of which, having the unchanged mineral at the centre, were transformed upon the surface to a dark purple, soft substance, easily cut with a knife. Between the purple zone and the topaz was a greenish, intermediate layer, which shaded off imperceptibly into the original nucleus.

Intimately associated with the topaz, in all the specimens received by us, was a mineral identified by Dr. T. M. Chatard as damourite. This mineral occurs at the locality in two forms; first, as a broadly foliated mica, much like a pale green musco-

* The microscopic and crystallographic work described in this paper is entirely due to Mr. Diller.—F. W. C.

† Chemical News, xlviii, 109.

vite, and sometimes very well crystallized; and secondly, as a massive, subfibrous, dark green variety, suggestive of steatite or serpentine. Both forms were analyzed by Dr. Chatard,* and the analyses have already been published:—they are reproduced here for comparison in series with those of the topaz and its alterations. The latter were analyzed by Mr. Edward Whitfield, who examined the topaz itself, the greenish intermediate layer, and the outermost purple product. The topaz was white, massive, and somewhat milky, and the method of analysis was, as in the case of Bradbury's work, the old zinc oxide process of Berzelius. The alkalies were estimated with the aid of the bismuth oxide method of decomposition, as proposed by Hempel, and modified in this laboratory by Chatard.† The results may be tabulated as follows:

A, unaltered topaz; B, greenish layer; C, purple zone; D, massive damourite; E, foliated damourite.

	A.		*B.*		*C.*		*D.*	*E.*
Sp. Gr.	3·51		3·42		2·82		-------	-------
Hardness	8.		7.		3.		-------	-------
SiO_2	31·92	-----	35·15	-----	44·52	-----	45·19	45·34
Al_2O_3	57·38	-----	53·18	-----	46·19	-----	33·32	33·96
F	16·99	17·21	12·88	-----	0·40	0·38	-------	-------
H_2O	0.20	0·20	0·90	0.90	3·74	3·99	4·48	4·78
K_2O	0·15	0·12	1·52	-----	2·30	-----	11·06	10·73
Na_2O	1·33	1·18	1·28	-----	2·82	-----	1·57	1·49
FeO	------	-----	------	-----	------	-----	4·25	3·96
MnO	------	-----	------	-----	0·21	-----	0·58	0·51
CaO	------	-----	1·32	1·42	0·30	0·48	trace.	0·22
MgO	------	-----	0·17	0·14	0·14	-----	0·36	0·10
	107·97		106·40		100·62		100·81	101·09
Deduct oxygen	7·16		5·42		·16			
	100·81		100·98		100·46			

If we now consider these analyses in their order, we find first that the topaz itself is ordinary topaz, having none of the anomalous character indicated by Mr. Bradbury's work. The small quantities of alkalies present may be attributed either to admixed impurity, or to an incipient alteration such as is suggested by analyses B and C. The latter point clearly to a progressive change from topaz towards damourite, the fluorine and some alumina having been gradually eliminated and replaced by other constituents. This change was probably brought about by the action of potash solutions, produced by the kaolinization of adjacent feldspathic material, the removal of fluorine and alumina having been followed by the taking up

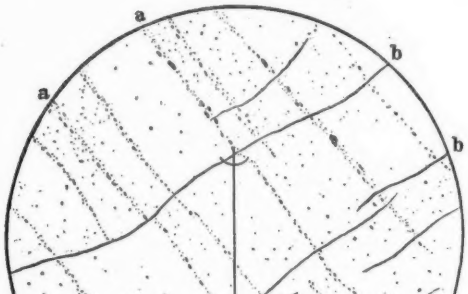
* This Journal, July, 1884. Also Bulletin No. 9, U. S. G. S.

† Bulletin No. 9, U. S. G. S., 1884.

of potassium. One preliminary experiment, bearing upon this mode of alteration, has been tried. A weighed quantity of the topaz, in fine powder, from the sample which was analyzed by Mr. Whitfield, was digested on the water bath for seven days with a weak solution of potassium carbonate. Then, after filtering, the amount of fluorine in the filtrate was estimated, and found to be 0·38 per cent. of the weight of topaz taken. That is, fluorine can be slowly extracted from topaz by the suggested process, although further experiments are needed to make the case anything like complete.

Inasmuch as the chemical analyses alone do not prove completely the change from topaz to damourite, microscopic slides were made and examined, using the specimen which showed the alterations most perfectly. In this specimen the purple zone had a thickness of about one centimeter, and exhibited on its surface the crystalline faces of topaz. On other altered specimens even the topaz striæ were distinctly visible. By means of the well-marked basal cleavage it was easy to determine and prepare particular sections parallel and perpendicular to the vertical axis, and both sections extended from the outside of the purple border into the fresh topaz. In the basal section the position of the brachypinacoidal plane was readily determined by means of the plane of the optic axes, which is represented by the vertical line in the middle of fig. 1.

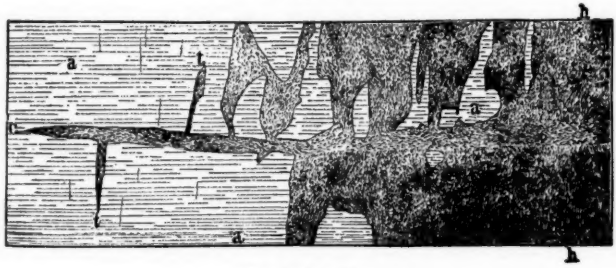
1.



Basal section of a Topaz Crystal.

In the topaz there are many liquid inclusions (*a*, *a*, fig. 1) from which the bubble readily disappears upon heating; and these are usually arranged in planes extending in nearly the same direction as, and approximately parallel to the most common prismatic planes *I* and $i\text{-}\breve{2}$. Almost at right angles to these, as represented in fig. 1, are numerous fissures, (*b*, *b*); which lie for the most part near the same prismatic planes. The fissures represented in the lower right-hand portion (*c*) of the figure are filled with a finely foliated, micaceous mineral, whose physical and optical properties, as far as they can be observed, agree fully with those of the damourite which was subjected to analysis by Dr. Chatard. The foliæ of damourite occur in fissures only; and although considerably interwoven, they are for the most part nearly parallel to the fissures in which they lie. The same fissures (*t*, *t*) are seen in a vertical position in fig. 2, which represents a section perpendicular to

Fig. 2.



Vertical section.

that shown in fig. 1; i. e., parallel to the vertical axis of the topaz. In fig. 2 the basal cleavage of the topaz is plainly seen (*a*, *a*); and nearly parallel with it are prominent cross-fractures, one of which is represented near the middle of the section (*c*). The damourite extends far into the topaz along these basal fractures in the form of veins, and from the latter it sends off tongues into the prismatic fissures. These, as shown in the figure, gradually increase in size from left to right, until the topaz entirely disappears, and the whole mass is made up of scales of damourite. The position of each scale bears no definite relation whatever to the crystallographic axes of the topaz; although the foliæ are generally parallel, they are often irregularly interwoven. The fact, as shown in fig. 2, that between the mass of the topaz and the damourite, there is an intermediate zone in which both are intermingled, is exceedingly important. Furthermore, the damourite always occurs in

fractures belonging to the topaz; indicating clearly that the fracturees were formed before the damourite, and determined its position. The basal fissures of the topaz, which depend upon its basal cleavage, once extended directly through the place now occupied by damourite, showing that the same space was once filled by topaz, and that the former must be an alteration product of the latter.

It will at once be seen that the crystallographic and microscopic evidence is even more emphatic than the chemical analyses in pointing to the conclusion that the altered topaz is essentially damourite. And yet, if we compare the analysis of the purple material with the typical damourite examined by Chatard, we find that the transformation is chemically not quite perfect. More alumina must be lost and more potassium must be gained before the alteration can be considered completely damouritic; or, in other words, certain stages of the chemical process, although easily to be understood, are yet to be actually observed on specimens of minerals. The state of the case, as it stands in the actual specimens under consideration, is probably as follows: Analysis A represents practically unaltered topaz; B, a mixture of topaz, damourite, and an intermediate alteration product; C, a similar mixture, with the topaz almost wholly removed and the damourite overwhelmingly predominating. The intermediate product, which is perhaps microscopically identical with topaz itself, should be simply the latter species with its fluorine replaced either by oxygen, by hydroxyl, or by both; and its formation is probably a necessary antecedent to the production of the damourite. The loss of fluorine appears to have preceded the taking up of alkalies.

In order to make clear the relations between topaz and damourite, we may profitably consider a few structural formulæ. Reduced to its simplest empirical expression, the composition of typical topaz corresponds to the formula $Al_2F_2SiO_4$. This may be written structurally in seven different ways; three being as follows, and the others variations of these:

1. $F_2=Si<\begin{matrix}O-Al=O\\O-Al=O\end{matrix}$

2. $SiO_4\begin{matrix}=Al-F\\=Al-F\end{matrix}$

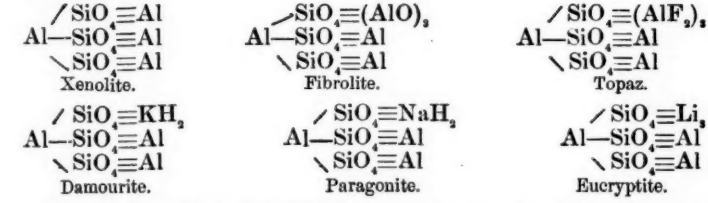
3. $Al\begin{matrix}=SiO_3\\>O\cdot\\=F_2\end{matrix}\quad Al$

The first formula is rather improbable, the second represents an orthosilicate, the third falls under a metasilicate type. Which one is best supported by evidence?

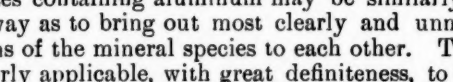
A prime difficulty in the way of discussing the chemical structure of minerals arises from the fact that we have as yet

no trustworthy means of ascertaining their true molecular weights. The formula of topaz, for example, may either be the simple expression given above, or a multiple of that; and our only method of even approximately solving the problem is to study the reactions of topaz, or, in other words, its modes of alteration. Now the simplest formula for pure damourite, and one which is commonly recognized, is $Al_3KH_2(SiO_4)_3$. That is, damourite is far more readily and probably figured as an orthosilicate than in any other way; and this fact tends to sustain the orthosilicate formula for topaz.

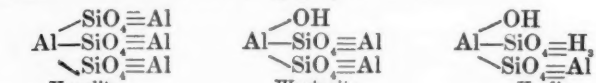
Inasmuch as the formula of damourite contains three SiO_4 groups, we may now triple the simplest formula for topaz, and write in probable structural fashion the formulæ of the two minerals side by side. The results will be suggestive, even standing by themselves; but more so if we consider at the same time a number of other allied species. These are xenolite, fibrolite, paragonite, and eucryptite. Xenolite, which is optically identical with fibrolite, has been reëstablished as a distinct mineral by the analysis of Wiik; fibrolite is unquestionably related to topaz; paragonite is the sodium analogue of damourite, and eucryptite is especially noteworthy for its alterability into hydro-mica. Tripling the formulæ commonly assigned to fibrolite and eucryptite, the series may be presented as follows:



Xenolite, it will be observed, is the normal orthosilicate of aluminum, and from it, by a simple process of substitution, the others may be directly developed. In a future paper an effort will be made by one of us to show that the formulæ of all orthosilicates containing aluminum may be similarly derived, in such a way as to bring out most clearly and unmistakably the relations of the mineral species to each other. The system is particularly applicable, with great definiteness, to the orthosilicate micas, and even shows the derivation of metasilicates from them; as in one case which may be fairly presented here. If we simply withdraw from damourite the elements of water, a mixed ortho- and metasilicate will be formed,—thus:



Two other derivatives of this group of compounds may be cited for example of an extension of this process, namely, westanite (or wœrthite, a hydrous fibrolite) and kaolin. If half of the water in the latter mineral be regarded as water of crystallization, the formula of kaolin will become that of xenolite with an aluminum atom replaced by three atoms of hydrogen; but if all the water be regarded as combined, the statement takes the following graphic form:



Xenolite. Westanite. Kaolin.

The suggestiveness of such formulæ can hardly be questioned, and a close examination of them will show that they also fulfill the main purpose of structural formulæ; namely, that they indicate probable lines for fruitful synthetic research.

One more question may be included within the scope of the present paper. What has become of the fluorine withdrawn from the topaz during the process of alteration? The answer is probably not far to seek. Leached out from the topaz in the form of alkaline fluorides, it entered into new modes of union, and these are represented at the locality by the species fluorite, herderite, triplite and apatite. The last-named mineral occurs in small crystals, and also in large, dark-green masses. As an analysis of the massive apatite was made by Mr. Whitfield, we subjoin it, as a further contribution to our knowledge of the locality. The specific gravity was 3·27, and the mineral became colorless on heating.

CaO	47·60
MgO	6·08
FeO	1·44
P_2O_5	40·36
Cl	0·29
F	6·84
H_2O	0·11
	102·72
Deduct oxygen	2·94
	99·78

The high proportion of fluorine found in this analysis was undoubtedly due to intermixed fluorite. The large amount of magnesia, moreover, suggests the desirability of a careful search at the locality for wagnerite.

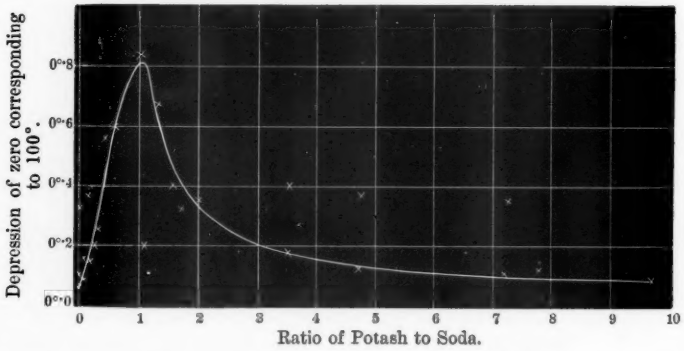
In conclusion, we must express our indebtedness to Mr. Whitfield for the care and thoroughness with which he executed the troublesome analyses.

ART. L. — *A notice of the relation observed by Dr. Weber between the residual elasticity and the chemical constitution of glass;* by O. T. SHERMAN.

IT is well known that the temperature of a bath, measured by a thermometer which has been long unused, is somewhat greater than when measured by the same thermometer immediately after it has been heated to a higher temperature. With a bath near the temperature of melting ice and a thermometer previously immersed in the steam of boiling water the depression may amount to a degree. The effect varies with the constitution of the glass forming the bulb. In any glass the depressions are capable of being expressed by an algebraic formula and the amount may be calculated. To make the temperature record independent of the condition or past history of the thermometer has proved a rather complex problem. The earliest attempts, regarding the depression irregular, adopted as the fundamental distance the interval between the freezing and boiling points obtained after a long rest, and for the false position of the zero, applied a correction proportional to the first power of the temperature. In 1880 it was shown that better results were obtained by considering the interval between the fixed points obtained directly after heating as the fundamental length, and calculating the position of the zero by a formula depending upon the second power of the temperature. A third method determines the errors of the instrument directly after it has been heated to the boiling point, and for lower temperature uses the instrument only when in the same condition. To diminish the uncertainties from this cause the Normal-Archungs-Commission has for some time past been analytically and synthetically examining the constitution of the glass which gave the least depression. In volume xxxvi of the "Sitzungsberichte der Königlich Preussischen Academie der Wissenschaften zu Berlin," Dr. Weber has recently stated as the first result of their work: that glass has the least depression in which the ratio of soda to potash or potash to soda is the least. In a previous number of the same publication, Dr. Weber has given twenty-three analyses of the glass together with the observed depression. It is a matter of interest to discuss these with regard to the same point. In the following curve we have represented the records of both articles. The ordinates represent depressions in tenths of a degree centigrade, the abscissæ, the ratio of potash to soda.

It will be seen that while the greater portion of the observations may be represented by a smooth curve yet six or at least

five lay farther from the line than can be ascribed to error of observation. In some of the irregular cases the composition of the glass is almost identical with some of those that lie on the curve. With one exception the departures are less than the maximum differences afforded by the depressions observed by Dr. Weber on a single thermometer. These latter, for ex



ample, amount to 0·21°, 0·29°, 0·35°. May it be that for certain proportions of soda and potash the depression becomes less regular? The single remaining exception, the only case where the depression is decreased, is unique in having the lime, soda and potash in nearly equal amounts. The Commission still continue the investigation.

Art. LI.—*On the Meridional Deflection of Ice-Streams;* by W. J. McGee.

I.—The Phenomena.

Five Quaternary glaciers, averaging eight miles in length, flowed down the picturesque easterly front of the cloud-capped Sierras into the broad valley of Mono lake in Eastern California. The glaciers have melted away beneath the withering winds of the geologic to-day; but their magnificent moraines tell of their magnitude and of their movements.*

The lateral moraines of four of the glaciers extend far upon the plain in which the lake is embosomed; while those of the fifth terminate on a narrow plateau bounded lakeward by an

* These and other moraines are described in detail by Mr. I. C. Russell (under whose direction they were observed by the writer), in his memoir on the Quaternary history of Mono Lake, designed for publication in the forthcoming Sixth Annual Report U. S. Geological Survey.

outlying butte. These five pairs of moraines possess the common feature of distal curvature northward.

Of the northernmost pair, issuing from Lundy cañon, the left-hand (northern) moraine is narrow and steep-sided—rising on both inner and outer sides at an angle of some 30° to an altitude of fully four hundred feet,—and curves northward so sharply as to almost follow the mountain-wall in which the cañon is excavated. The inner side of the right-hand moraine is equally steep and of concentric curvature; but its summit forms an undulating plateau half a mile broad, expanding, fan-like, toward its extremity, and sloping gently outwardly and distally toward the lacustral plain of Mono, into which it gradually merges. Near its origin in the embouchure of the cañon, the highest of the Quaternary lake-terraces encircling the valley is as distinctly scored upon the outer slope of this moraine as upon the contiguous mountain-side; but toward its extremity the wave-marks become progressively fainter and finally obscure. Beyond occur fractured and contorted lacustral strata overlain by only five or ten feet of coarse littoral deposits, indicating that the glacier reached its greatest extension just before the waters attained their highest level.

In its upper course, Leevining cañon is a deep, narrow chasm, but it expands lakeward and opens on the plain in a broad breach bounded on the south by the isolated butte behind which the Gibbs cañon glacier terminated; and its moraines originate with the expansion. That on the left is narrow, steep-sided, and sharp-crested, and closely hugs the northern cañon-wall nearly to the wide embouchure, where it attenuates and finally disappears, leaving only the precipitous mountain-side for the northern confine of the ancient ice-way. The right-hand moraine sweeps about in a concentric curve interiorly, but has a multipartite crest, widens distally, and exteriorly sends off four or five digitiform radial spurs obviously the right-laterals of successive stages in the development, repeated oscillation, and final decadence of the glacier; while, unlike its constricted northern fellow, it shuns the southern cañon-wall, leaving a considerable valley between moraine and mountain-side.

The moraines issuing from Gibbs cañon are of consonant behavior: that on the north is compressed, and finally abruptly terminated by the chasm through which this ice-stream, in its later stages, approached and perhaps became confluent with the deeper Leevining glacier; while a broad morainic plain, diversified by half a dozen obscure radial lobes, forms the left lateral and occupies the greater part of the plateau separating Leevining and Bloody cañons. These moraines record the gradual shifting of the periodically oscillating ice-stream from

the southern to the northern margin of the plateau, and its ultimate coalescence, just before the final recession of the ice—with its northern neighbor.

Bloody cañon embouches into a broad bay forming the southwestern arm of Mono valley. Its magnificent moraines do not closely approach either side of the bay after leaving the cañon proper; but their northward curvature is pronounced. That on the right is conspicuously the broader and more massive, and sends off two or three digitiform lobes analogous to those of the Leevining and Gibbs moraines; and midway of its length a symmetric pair of perfect laterals spring from its graceful curve like the tangent from its chord, and extend directly into the bay nearly as far as do their more recent homologues. Here the deflecting agency manifestly forced the fluctuating ice-stream to burst its old barriers and build for itself a new pair of adequate curvature.

The southernmost of the five pairs of moraines issues from Parker cañon and extends two or three miles upon the long alluvial slope everywhere forming the periphery of the plain of Mono. They curve northward more sharply and approach the northern cañon-wall more closely than do those of Bloody cañon; but the right-hand member does not so greatly exceed its fellow in magnitude.

Let it be clearly understood that in these several cases the curved portion is well without the cañon proper and unquestionably beyond its influence, and that the curvature, so far as can be detected by careful observation, is independent of if not opposed to topographic configuration, whether ancient or recent.

So uniform behavior must have a common cause; and this may be sought analytically.

II.—The explanation of the phenomena.

Let an ice-stream flowing east or west on a meridionally horizontal plain in N. lat. 45° have cross-section bounded above by the transverse semi-circumference of an ellipse whose axes are 2 and 1 respectively; and let the sun be over the equator. The proportion of solar rays directly reaching the south and north halves respectively, will then vary as $a-b:b-c$ (fig. 1); or, making the major semi-axis unity, as 1·5000 to 0·6547 (= sec. 30° − 0·5000), since the secant formed by the tangential ray in such case is demonstrably equal to the like function determined by the tangent to a circular arc of value 30°. The relations are graphically shown in fig. 1.

1.

The whole of the solar energy reaching the ice-stream will not, however, be utilized in affecting its condition;—a considerable portion will be lost by direct reflection; and of the remainder the discordant (and hence heating) rays will have been in part absorbed by the vapor of the superfluitant atmosphere; but the diminution will be proportional.

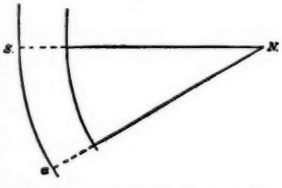
Again, an important share of the heat absorbed by the glacier will be derived from the surrounding air, from the earth beneath, and, by reflection and radiation, from contiguous earth, rocks, hills, etc.; and this share will be pretty nearly equally distributed over the entire surface. If half the effective heat reaching the ice comes from such sources, the ratio of effective energy received by its respective halves will be reduced to 25773 : 17320.

Also, the differential accession of the two halves will be counteracted to a considerable but indeterminate extent by interior conduction. If the unequal distribution be thus diminished by a half, the ratio will be further reduced to 23660 : 19433.

Now, as empirically shown by innumerable observations, and as theoretically indicated by all plausible hypotheses of glacier motion, the rate of movement of ice-streams varies directly with the heat-accession or with some slightly variant function of that element. If, then, in the assumed case, the accession be incompetent to occasion loss by melting (i. e., if on any section of the stream daily accession equal nightly radiation), all will be effective in producing movement, the two halves will tend to flow at rates varying with the accession, and the stream will hence tend to curve in the direction of the slow-moving side.

Such tendency will be counteracted in part by (1) the mobility of the ice (which will permit the southern half to the more readily spread laterally and to slip past the northern half to some extent), and (2) by the increased friction encountered with lateral shifting of the stream. Accordingly, the loci of flow in the determined ratio will lie somewhere without the centers of the respective halves—perhaps at the extreme edges of the glacier; when these edges will curve northward in concentric arcs of 23660 and 19433 respectively, or of 5598 feet and 4598 feet radii if the width of the stream be 1000 feet. Such curvature is shown in fig. 2.

2.



If the direction of flow depart from the parallel, other elements are introduced. To facilitate their comprehension, let

the ice-stream be assumed to flow north or south upon a plain horizontal in the trans-meridional direction; and, as before, let the heat accession be supposed insufficient to produce melting. Neglecting interception by clouds (which is rendered nugatory by concomitant diminution of diathermancy and increase of liberation of latent heat by condensation of vapor), insolation on the two halves of the glacier will then be equal; but the influence of the thermal energy in affecting the mobility of these halves will become unequal by reason of (1) the variable condition of the atmosphere, and (2) the diverse offices of the absorbed energy, at different hours.

The diurnal inequality in temperature is notable in most and appreciable in all stations affected by glaciers; so, in such stations, the forenoon is lower than the afternoon temperature. In general, atmospheric diathermancy varies inversely with temperature, and afternoon precipitation predominates, in glaciated as in most other stations. Accordingly, the solar accession of the east half of the assumed ice-stream will be freely dissipated through the diathermous forenoon atmosphere, while the west half accession will be not only conserved by the athermous afternoon atmosphere, but supplemented by the latent heat liberated by afternoon precipitation.

The thermal energy derived by the glacier from all sources is arbitrarily divisible into two shares expended respectively in molecular and molar work, or in (1) elevating the temperature of the ice from that of inter-stellar space to that of mobility, and (2) mobilization. During the forenoon when east half insolation predominates the share of energy absorbed in molecular work is larger, by reason of the lower temperature to be overcome, than during the afternoon when the west half faces the sun. It follows that the share of energy available in mobilization during each day will be the greater in the west half of the glacier.

Thus the west half of the meridionally-moving ice-stream not only absorbs more heat than the eastern half, but utilizes a larger proportion of it in generating movement; whence it must tend to outrun its eastern mate, and thus to originate eastward curvature of the stream. Such tendency depends for its strength upon many obscure elements, and hence cannot be quantitively expressed. It is probably slight in the case of the meridional ice-stream and of progressively diminishing value as the direction of flow approaches the parallel; but it cannot be neglected.

So many of the factors essential in the foregoing analysis are indeterminate or variable that the numeric ratio deduced above can only be regarded as a vague approximation even in the simplest case; and it is accordingly needless to deduce in

like manner similar estimates for different latitudes, for the several seasons, and for diverse directions of flow.

The relation of the factors is such, however, as to indicate the general law that *ice-streams flowing upon plains are deflected toward the sides upon which effective solar accession is least.*

The law is modified in its action by conditions originating with the formation of moraines by the ice-stream, and by conditions affecting the origin of the ice-stream itself.

In nature the ice-stream, after leaving its parent cañon, flows not upon a plain but in a trough whose walls it builds upon the plain. Now after its first formation the northern moraine must ever oppose the tendency to further deflection; and moreover, with the development of the moraines the surface of the stream will diminish in convexity. In nature, too, some melting of the ice will surely occur, and whatever energy is expended in liquefaction will be diverted from mobilization; and since liquefaction will occur chiefly on the south side, that side will be attenuated and rendered less competent to deflect the stream. For these four reasons will the deflection tend to fail of that computed.

If, however, the northern moraine be forced outward by the impinging ice, the stream will follow it and leave a gash between ice and moraine on the south to be filled with supraglacial debris; and whatever melting and attenuation the south side suffers, will lower that side, shift the medial axis northward, and bring more than its share of debris to the southern moraine; which thus for two reasons will tend to widen.

But again, in nature the ice-stream does not possess constant volume and length; it alternately expands and contracts, vertically, laterally, and longitudinally. In its contraction both moraines will be reinforced by semi-terminal deposits greater on the south, but their status will otherwise remain unchanged. In its expansion, however, it will press upon both moraines; when if either yield it will be the weaker northern one. Also the old channel will be plowed out anew; when, if the curving glacier hug its northern wall, there will the furrow be deepest and the lateral abrasion greatest. Moreover, the swelling stream will eventually overtop its ancient banks and discharge on and over their summits its superficial debris; when that on the north will fall beyond the narrow crest and roll down without, while that on the south will spread itself over the already broad-topped ridge. Thus for three further reasons will the meridional deflection tend to approach that computed.

Finally, if the oscillating glacier break out of its trough, the trench will occur in the feebler and more strongly constrained northern barrier.

Within the cañon proper two antagonistic elements ever work. The greater number and extent of tributary glaciers on the northerly slope will increase both ice and debris there, and thus tend to deflect the stream northward and build up the southern moraine; while on the southerly slope the greater variability of temperature will augment disintegration and the more effective reflection and radiation will accelerate the flow on that side, and thus tend to deflect the ice-stream southward and build up the northern moraine.

The modifications in the action of the general law due to external conditions are, accordingly, not such as to affect its validity or materially reduce its potency.

The law of meridional deflection of ice-streams here educed appears adequate to explain the common curvature of the moraines of the Sierras.

February 18, 1883.

ART. LII. — *The Pre-glacial Channel of Eagle River, Keweenaw Point, Lake Superior;* by CHARLES WHITTLESEY.

INTRODUCTION.

IN the year 1854, the author examined the scattered and mutilated maps made in the progress of mining at the Phœnix location, on Keweenaw Point, Lake Superior, and compiled from them, with the aid of the descriptions of Superintendent Hill and Captain Paul, a map and a series of profile-sections that illustrate the main features of the mining operations previous to that date. In an accompanying letter to Superintendent Hill, under date of December 27, 1854, he communicated some discoveries relative to an ancient and deeply-buried channel of the Eagle River. At that time such facts were regarded more as curiosities than as valuable data. Recently, however, more attention has been given to this class of phenomena, and all facts relating to the ancient drainage systems are regarded as having permanent value. So much of the report as relates to this subject is, therefore, now given to the scientific public with some unimportant modifications, made for the convenience of the reader, who might not otherwise readily understand some of the references. The maps and sections have been reduced and somewhat simplified by the elimination of matter not deemed important to science.

Discoveries in the progress of mining and interpretation of the results.

The papers found in the Phœnix Mining Company's office relating to the working of their mine in 1846 and 1847 were carefully examined. The plans, surveys, levels and sketches of Mr. Martin Coryell were found to be very numerous, but were mutilated, and many had been lost. Without the personal explanations made by Superintendent S. W. Hill, and, particularly, those of Captain Paul, of the North America Mine, it would have been very difficult to have made from these fragments a reliable plat, which should show the state of the old works. I did not ascertain how much of the material that related to the first three years of their operations under the old charter was preserved by the Company's agents in Boston.

The works were so singular as to interest every one acquainted with mines or mining geology; and there were, in those first developments, certain facts shown that were of economic value as well as scientific interest. But my object in bringing together on one map-sheet the information left by Superintendent Coryell was at first one of mere curiosity. The plan and sections, which were thus produced, show, I think, all the material features of the old works, and represent them in very nearly their correct positions and proportions. They are sufficiently full and well explained on the sheet itself, so that little remains to be said in reference to the mine-work proper. I have connected with the plans, such geologic profiles as are necessary to illustrate the ancient state of things; and have laid down the different beds of trap rock which originally held the copper, that was found in the form of water-washed bowlders.

After the shaft marked No. 2 on the map had been sunk in the rock near the bank of Eagle River, to the depth of 62 feet, a cross cut was made to the east from the bottom of the shaft. This was done to explore the ground. To the great astonishment of every one, the miners, at a distance of about 20 feet from the foot of the shaft broke through into sand and gravel. This was 32 feet below the channel of the river (really but a creek, at this point), where the water was then flowing. It happened, also, to be on a level with the bottom of the drift-filled gorge; so that the miners proceeded along its rocky floor in the hope of further discoveries. A few feet forward, they cut the back of a well defined vein. A mass of earth, bowlders and gravel lay on either hand and overhead, and was so compact as to stand firmly as the gallery progressed. Captain Paul thinks it remains so now, although very little timber was put in.

The general direction of the glacial striæ on Point Keweenaw is from the northeast towards the southwest, and therefore within about 25° of a perpendicular to the course of the ancient channel of Eagle River, at the Phœnix Mine. In moving across the old channel the pressure of the ice mass was such that the drift materials were made nearly as compact as rock. Glaciated surfaces in the vicinity reach upward from the lake level to the top of the semi-mountainous range, an elevation of 700 to 1,000 feet, from which it appears that the ice had a very considerable thickness.

At the point where the miners happened to strike the rock floor of this old channel, there was a steep rise in the rock bottom, on the right hand side; and they followed awhile along the foot of this slope. The boulders that were found in the "hard pan" were held firmly in it, either by pressure or by cement, and were of various kinds of rock, as sandstone, trap, granite, porphyry, etc., the same as are common in the Lake Superior drift-deposits. These were very much water-worn. On the back of the vein, and in its vicinity, there were rounded lumps, and grains of native copper, of all sizes, some of them still bright and shining.

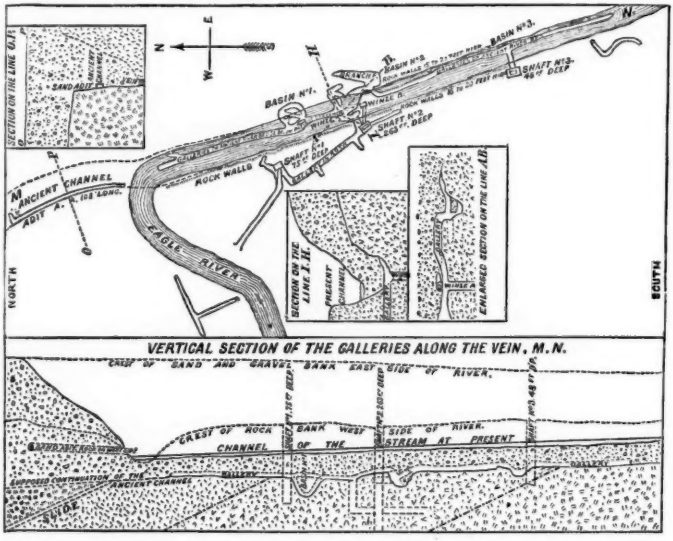
These discoveries tempted them on; and turning to the left or to the north, they followed along the vein. They were evidently in the bed of an ancient stream, the predecessor of the Eagle River, as it existed at some remote period. Along the lowest part of this lay the vein which perhaps determined the course of the stream. For about thirty feet the floor was not found to be very uneven, but, as it here sunk below drainage level, a branch gallery, D, was started obliquely to the right. At 27 feet, in this direction, the gallery being entirely in drift, a rock face was struck. The gallery, thus made, proved to be the diameter of a circular cavity, (marked "Basin No. 1," on the map) which was found to be 17 feet deep.

The miners then followed around the rim of the basin, and also descended nearly to its bottom, taking out large quantities of loose copper and copper-bearing gravel. One mass, from the level, near the basin, weighed 1,760 pounds. This basin appears to be a gigantic pot-hole.

On the northwestern quarter of the basin, a narrow fissure was discovered, which represented the vein; and along this the miners worked to the distance of 174 feet from winze A (see map), which had already been sunk on the vein. The bottom of the gallery in this direction was not very uneven, and descended but slightly to the north. The earth of the gallery sides remained firm; but on the 16th of November, 1846, a stream of water was struck which discouraged the superintendent, and the work was abandoned.

The stream copper was found to lie always next to the rock, and not intermixed with the drift material above. It was collected most abundantly in the concavities and irregular depressions of the floor, but it was not sufficient in amount to pay the expense of mining.

When it was abandoned, the gallery had reached a point almost directly underneath the bend of the river, as shown on the map. On the surface, directly beyond, was a face of rock



rising from the water 15 or 20 feet. The present channel of Eagle River below the bend has rocky sides and a rock bottom, the lowest part of which is at least 20 feet higher than the end of the gallery.

These facts raise the question: Where did this ancient channel discharge itself? The river between shafts numbered 2 and 3 has rock walls on both sides rising 15 or 20 feet high. Near shaft No. 2, the east wall disappears beneath sand and gravel, which rises from the water level on the east bank about 90 feet. From shaft No. 2, to the bend, the rock is seen in place only on the west side. The branches subsequently worked did not disclose a vertical face on the east side, like the one on the west, but such a one must exist somewhere beneath the gravel.

On the north side of the creek, at the bend to the west, an adit A, A, was driven in along a vertical wall corresponding in

direction to that of the west bank, in the expectation constantly of striking the vein. It kept the wall on the left hand for a distance of 108 feet, no rock being found on the right or bottom. A cross heading was then cut 12 feet to the east, but no rock found in place. The bottom of this adit is about 50 feet higher than the gallery along the bed of the ancient channel, the extremity of which is nearly under the mouth of the adit.

Notwithstanding the want of success in this direction, the managers continued to work the galleries which joined at winze A, in various directions, taking out a large amount of float copper, and of gravel bearing sufficient copper to pay for washing. Among this were found frequently pieces of native copper and silver united in a single mass, but each metal in its pure state, without alloy.

The bed of the ancient channel was found to descend to the north by offsets or sudden leaps which were doubtless ancient falls. In its bottom were also pockets, precisely like those of the present channel, where the descent is rapid over ripples and ledges. Captain Paul, who worked in those levels, says: "No one could mistake the cavities and pot-holes for anything else than the action of running water."

Going south the vein was well defined, both walls being visible most of the way, and well charged with copper. But the loose copper gradually diminished, and in May, 1847, at a distance of 260 feet from winze A, the work was suspended.

The strata of trap through which the vein passed and in which it bore copper are as follows: Beginning at the north, or left hand, there is a coarse porous bed of amygdaloid, which Mr. Coryell cut in his adit at 52 feet from its mouth. This dips to the north at the usual angle of 25°. Under it is a close-grained, bluish-black, compact bed of trap, about 50 feet thick, which has a basaltic, or columnar, structure. Underneath this is "the slide," which is so distinctly shown at the Copper Falls Mine, west vein, near shaft No. 5. The bed beneath "the slide" is a rough mass intermediate in character between a breccia and a conglomerate, embracing nodules of sandstone and of scoriaceous tufa imbedded in a dark brown trap. Shaft No. 1, was sunk in this bed, which was found to carry "shot copper" near the middle of its mass. Its thickness is irregular, but, on an average, is about 50 feet. It rests on a bed of black, fine-grained, compact trap from 80 to 100 feet thick, extending on the surface from shaft No. 2, to some 100 feet south of shaft No. 3. This "black band" has well-defined faces and dips to the north at the usual angle. Beneath this is a soft, greenish-gray bed of great thickness in which the workings of the new company are principally situated.

The stream copper lay in the scoriaceous, or "ash-bed," stra-

tum, and in the "black band" beneath it. As these pitch to the north at an angle of not more than 25° with the horizon, they pass away from the recent works, so that they were not proven by the sinking of shaft No. 3, or the levels connecting with it. These beds should carry copper in the vein as they descend northward toward the lake.

There can be no doubt that the river, before the drift period, held on its way to the lake along the course of the vein, and did not then turn to the left, as it does at present. Without doubt its bed continued straight along the face of the rock seen in the adit A, A, and 35 or 40 feet beneath it, and presented at that period an open gorge like the present one, only deeper and wider. The whole was filled up to the depth of 100 to 120 feet, by the agencies that brought in the drift material. During the period next preceding the drift epoch, and while the stream of water ran along the back of the vein, it wore away the vein matter and wall rock leaving the masses of copper at rest in its channel. With the facts shown by the plans and sections I do not see how any other explanation is applicable. The ancient channel perhaps had its discharge at a lower level than the present one, and somewhere to the northward, either again joining the present course, or reaching the lake by a separate mouth.

Captain Paul represents the vein in the "sand galleries" [galleries excavated in drift material, instead of rock] along its whole exposure of more than 400 feet, as well charged with copper, and is confident that the same "pitches" of rock carry copper in masses. The floor of the "sand gallery" is about 175 feet above the lake. The dip of the strata carries the copper-bearing beds to the north, as they descend, about two feet horizontally for one vertically, or a distance of 350 feet in the depth of 175, i. e., to the lake level. The true approach to these beds is therefore from the north and at the lowest practicable level.

ART. LIII.—*Note on the Age of the Slaty and Arenaceous rocks in the vicinity of Schenectady, Schenectady County, N. Y.;* by S. W. FORD.

THE slaty and interstratified arenaceous rocks in the neighborhood of Schenectady, N. Y., have usually been referred to the epoch of the Lorraine Shales. They were considered to be of that age by Mather, who gives several sections of them, in their more eastward extension along the valley of the Mohawk, on

page 376 of his Report on the Geology of the First District of New York; and the same view appears to have been held by Emmons (Agriculture of New York, vol. i, pages 134, 135, 1846). Later, Mr. R. P. Whitfield, in a letter addressed to Dr. C. A. White, and published in Part I, vol. iv, of Lieut. Wheeler's Reports on Geographical and Geological Surveys west of the 100th meridian, considers the Schenectady rocks to be of Lorraine age, but does not support his position by the evidence of fossils obtained at that locality. He also refers to the Lorraine certain "disturbed and nearly vertical layers" occurring in the valley of the Norman's Kill, near Albany, which, he says, are lithologically undistinguishable from the rocks at Schenectady; and places the Norman's Kill Graptolitic beds, which are met with only a few hundred yards distant, in the Utica formation. Mr. Whitfield is quite possibly correct in considering the nearly vertical layers above spoken of identical with the Schenectady beds; but it by no means follows from this that the layers are Lorraine, or that the Norman's Kill Graptolitic beds are Utica.

The rocks at Schenectady are nearly horizontal, or with only a slight inclination to the southward, and continue in that position for three or four miles to the east. Not far from Rexford flats a break occurs, and from that point all the way to the Hudson the rocks are greatly tilted. The break here alluded to Dr. Emmons considered identical with the fault occurring at Saratoga Springs and Baker's Falls; and believed it to pass somewhere between Albany and Schenectady, and to be traceable in its effects as far south as Kingston. It appears to hold the same relation to the Great Appalachian fault that the Montmorency break does in Canada. I have never examined with care the slaty rocks directly *east* of the break along the valley of the Mohawk; but from the nearly horizontal beds to the west of it, in Wandell's quarry, a short distance back of Union College, at Schenectady, I have obtained good specimens of *Graptolithus pristis*, *G. mucronatus* and *Triarthrus Becki*; and from another quarry, a little to the west of Rexford flats, I have obtained the *G. pristis*, *Triarthrus Becki*, and a species of Lingula which I consider to be the Utica species *L. curta*. The slates and sandstones in the vicinity of Schenectady are, therefore, in my estimation, of Utica age. I find that the arenaceous layers are different in their make-up and aspect from those of the Lorraine that I have examined, and more nearly resemble those of the Utica formation of Northern New York. The rocks are poor in fossils; but fossils nevertheless exist, and may be found by diligently searching for them.

Schodack Landing, N. Y., March 5th, 1885.

SCIENTIFIC INTELLIGENCE.

I. Chemistry and Physics.

1. *On the Freezing Point of Saline solutions.*—Raoult has continued his researches on the action of dissolved substances in lowering the freezing point of solutions, and has now given the results of his experiments upon salts dissolved in water, classifying these: 1st, according to the value of the metallic constituents, and 2d, according to that of the metalloid or negative substance. In the first series, the salts are those of potassium, sodium, ammonium, silver, lithium, cæsium, and trimethylethylammonium. The tabulated results show that different salts of the same group, i. e., containing the same number of metal atoms in the molecule, show nearly the same molecular depression of the freezing point. The first group of this series, consisting of salts containing only one atom of the monad metal, gives values for the molecular depression varying from 27 to 36.* The second group, the salts of which contain two atoms of monad metal, gives the value 40. The third group, in which three monad metal atoms are contained in the molecule, gives the value 48. The fourth gives 47, and the fifth 48. The second series contains the salts of dyad metals, and the molecular depression does not exceed 53; the values being 41 to 48 for the salts of monobasic and 18 to 22 for those of dibasic acids. Comparing the two series, it appears that whenever in a molecule of a salt dissolved in 100 c. c. of water, one atom of an alkali-earth or earth dyad metal is replaced by an equivalent quantity of a monad metal, the lowering of the freezing point increases by a nearly constant quantity, viz: about 21. Referring the matter to equivalents, the author states his results in this form: If in the solution of an alkali-salt, containing one equivalent of the salt in 100 c. c. of water, the monad metal be replaced by an equivalent quantity of a dyad or polyad metal, the depression of the freezing point is diminished by a quantity sensibly constant and equal to 10·5. With regard to acids, the law given is as follows: If in the solution of a salt of a strong monobasic acid, containing one equivalent of the acid in 100 c. c. of water, the monobasic acid be replaced by an equivalent quantity of a strong dibasic acid, a diminution of the depression of the freezing point is observed which is nearly constant and approaches 14. From these data the author calculates the depression due to the separate radicals. Thus the electronegative monad radicals, such as Cl, Br, OH, NO_3, produce a partial depression of 20; the dyads, as SO_4, CrO_4, one of 11; the positive monad radicals, as H, K, Na, NH_4, a depression of 15; and the polyads, as Ba, Mg, Al_2, one of 8. From these partial values the molecular depression of any salt

* The molecular depression produced by a salt is obtained by multiplying the lowering of the freezing point of a solution containing one gram in 100 c. c. of water, by the molecular weight.

can be calculated from its molecular weight.—*Ann. Chim. Phys.*, VI, iv, 401, March, 1885. G. F. B.

2. *On the Influence of light on Chemical Reactions.* — Some time ago SCHRAMM pointed out that the action of bromine upon crude bromtoluene or upon a solution of parabrom-toluene in chloroform produced parabrombenzyl bromide even at 0° C., and hence that the substitution of an atom of hydrogen for bromine in the lateral chain did not require the aid of heat. The change takes place, however, slowly in diffused daylight, and much more rapidly in sunlight. The author has studied the phenomenon more closely and now concludes that the action of light is essential to it. If the solution of bromtoluene in chloroform is feebly colored with bromine as by blowing bromine vapor through it, and then placed in the dark, no action whatever takes place. But light decolorizes it at once with evolution of hydrogen bromide. The action of light upon the bromination of ethylbenzene is of particular interest because not only is this hydrocarbon under these conditions highly sensitive to the action of light, but it yields different substitution products according to the intensity of the light acting. If ethylbenzene is slightly colored with bromine, no decolorization takes place in the dark; but it loses its color at once in daylight or when exposed to burning magnesium. If a molecule of bromine be made to act on a molecule of ethyl-benzene in diffused light, a colorless liquid product is obtained which does not solidify at −20°. On distillation, HBr is evolved and a distillate is obtained between 140° and 190°, a dark brown residue remaining in the retort. No bromine product of constant boiling point could be isolated. The fraction between 140° and 160° united directly with bromine and solidified, forming dibromstyrene. The fraction boiling at 180°–190° did not combine with bromine and was probably styrene-ethyl ether. When the ethyl benzene is treated with a molecule of bromine in direct sunlight the reaction is violent and the final product is α-phenyl-bromethyl $C_6H_5—CHBr—CH_3$. More curious still is the replacement of the second hydrogen atom by bromine. If the operation be conducted in full sunlight the product is phenyl-bromacetene $C_6H_5—CBr_2—CH_3$. While if diffused daylight only be allowed to act upon it, the product is dibromstyrene $C_6H_5—CHBr—CH_2Br$.—*Ber. Berl. Chem. Ges.*, xviii, 350, Feb., 1885. G. F. B.

3. *On the Salts formed by Tellurium with Acids.* — KLEIN and MOREL have examined the compounds formed by tellurium with acids and have described the sulphate and the nitrate. Tellurous nitrate is obtained by dissolving finely divided tellurium in an excess of nitric acid of sp. gr. about 1·15 heated to 50°. By concentration the salt deposits on cooling in beautiful needles probably orthorhombic. Analysis shows it to be a basic nitrate of the formula $(Te_2O)_4N_2O_5$, $1\frac{1}{2}H_2O$. It is very easily decomposed by water and is very hygroscopic. When in solution it decomposes slowly in the cold, rapidly at the temperature of ebul-

lition, the nitric acid remaining in the liquid and the tellurous oxide being precipitated as a nearly white powder. Boiling for 20 minutes completely decomposes it, yielding 1·415 grams TeO_2 from 1·698 of the salt. Tellurous sulphate was obtained by dissolving the oxide in hot sulphuric acid diluted with 3 or 4 times its weight of water. On evaporating the solution on a sand bath, the sulphate was deposited in the form of scales, which under the magnifier had the appearance of orthorhombic tables. The excess of acid was decanted and the crystals dried on a plate of porous porcelain, the last trace of acid being removed by heating to the temperature of melting lead. Analysis showed this also to be a basic salt having the composition $(TeO_2)_2SO_3$. It is decomposed very slowly by cold water rapidly and nearly completely by boiling water, leaving tellurous oxide crystallized in microscopic octahedrons.—*Bull. Soc. Ch.*, II, xliii, 198, March, 1884.

G. F. B.

4. *On the Atomic Weight and on certain Compounds of Samarium.*—Clève has published an abstract of his recent researches on samarium. He finds that the best process for its separation consists in fractionally precipitating the mixed nitrates in cold very dilute solution by a dilute solution of ammonia. Samaria concentrates in the first fractions which are subjected to repeated precipitations until the absorption spectrum of didymium disappears. To free it from yttria, etc., it is then precipitated by means of potassium sulphate, which forms with the samaria a double salt only slightly soluble in the potassium sulphate. As thus prepared it has always a yellow color from the presence of terbia, from which it may be freed by repeated precipitations with ammonia. The final fractions are nearly white. The atomic weight was determined from the weight of sulphate yielded by a known weight of the oxide. Six determinations gave the values 149·975, 149·940, 150·120, 150·045, 150·045 and 150,000, the mean of which is 150·021. So that 150 may be taken as the atomic weight of samarium. The spectrum of this element has been examined by Thalèn who has mapped 198 lines. Its remarkable absorption spectrum has been studied by Soret, by Thalèn and by Lecocq de Boisbaudran. Soret has shown the existence of bands in the ultra violet and Becquerel in the ultra red. The metal has not yet been isolated. The oxide Sm_2O_3 is a nearly white powder of density 8·347 which dissolves easily in acids. Its salts have a yellow color like sulphur or a brown like topaz. Their solutions have a sweet astringent taste, and are easily precipitated by oxalic acid, the oxalate being almost insoluble. Samarium is determined either as oxide, by igniting the oxalate or hydrate, or as sulphate which may be heated to a dull red.—*Bull. Soc. Ch.*, II, xliii, 162, Feb., 1885.

G. F. B.

5. *On the Purification of Methyl Alcohol.*—The question of the production of iodoform by the action of iodine on methyl alcohol in presence of alkali hydrates has been an open one owing

to the difficulty of completely purifying this alcohol. Even when prepared by the decomposition of methyl oxalate there still remains in it some constituent which yields iodoform. REGNAULT and VILLEJEAN have now proposed to effect the final purification by the iodoform method itself. The alcohol prepared from methyl oxalate has about one tenth of its weight of iodine dissolved in it, and an aqueous solution of sodium hydrate is added to it in quantity sufficient to produce complete decoloration and leave an alkaline reaction. Submitted to careful distillation methyl alcohol is obtained which when rectified over caustic lime has a specific gravity of 0·810 at 15° and which does not yield iodoform.—*Ann. Chim. Phys.*, VI, iv, 430, March, 1885. G. F. B.

6. *On Phenol Coloring Matters.*—In the preparation of nitrosoresorcin and nitrosoorcin by the action of amyl nitrite upon the mono-sodium salts of the corresponding phenols and precipitation with dilute sulphuric acid, BRUNNER and ROBERT observed that after some time dark crusts separated from the wash waters which they at first took for azoresorcin and the corresponding orcin coloring matter. But a closer examination showed that only slight traces of these bodies were present, and that the mass consisted essentially of a new material. The nitrosoresorcin crust was washed with water, dissolved in ammonia, filtered and precipitated with hydrochloric acid. A brown substance was thrown down which ether separated into a soluble and an insoluble portion. The former remained after the evaporation of the ether as a cantharides-green mass, soluble in alkalies with a blue violet color, with a brown fluorescence, and soluble in concentrated hydrochloric and sulphuric acids. Analysis gave the formula $C_{18}H_{15}NO_6$. The authors believe this body to have been produced by the action of the nitrosoresorcin upon resorcin itself according to the equation:

$$\underset{\text{Nitrosoresorcin.}}{\begin{matrix}HO\\HO\end{matrix}\!>\!C_6H_3\!-\!N\!:\!O} + \underset{\text{2 mol. Resorcin.}}{H\!:\!O\!-\!C_6H_4OH \\ H\!:\!O\!-\!C_6H_4OH} = H_2O + \underset{\text{New coloring matter}}{\begin{matrix}HO\\HO\end{matrix}\!>\!C_6H_3N\!<\!\begin{matrix}O-C_6H_4OH\\O-C_6H_4OH\end{matrix}}\ C_{18}H_{15}NO_6.$$

It is therefore analogous in constitution to the coloring matters obtained by Krämer from nitrosophenol and nitrosoorcin, the former being $HO-C_6H_4N<\begin{matrix}OC_6H_5\\OC_6H_5\end{matrix}$ and the latter

$$\begin{matrix}HO\\HO\end{matrix}\!>\!C_6H_2(CH_3)N\!<\!\begin{matrix}O-C_6H_2(CH_3)OH\\O-C_6H_2(CH_3)OH\end{matrix}.$$

The residue insoluble in ether was dissolved in alcohol and left on evaporation a brown mass, soluble in alkalies with a dirty violet color. It appeared to be impure and was not further examined. —*Ber. Berl. Chem. Ges.*, xviii, 373, Feb., 1885. G. F. B.

7. *Application of the Pendulum to the determination of the mean density of the earth.*—The observations of MASKYLENE and HUTTON on the deflection of the plummet line in the neighborhood

of Schehallien are affected by an approximate knowledge of the mass and density of the attracting mountain. This error also affects the results of Carlini and Airy who used the method of oscillation of a pendulum. Generally the pendulum has been abandoned for the torsion balance. Dr. J. Wilsing, of Potsdam, however, has revived the use of the pendulum for the purpose of weighing the earth and shows that it can be made sufficiently sensitive by adjusting the center of gravity close under the axis of oscillation. An experimental apparatus consisted of a prismatic rod of thin sheet iron at the ends of which were fixed lead balls, each weighing 300 grams. The steel knife edge, which rested on agate, was fixed in the middle of the rod. When the apparatus was in equilibrium the axis was nearly vertical. The motion was read by reflexion. When the position of equilibrium was found and the attracting masses were placed near the lead spheres, from the deflection of the pendulum, the ratio of their attraction to the constant of gravitation can be determined. By reversing the direction of the deflecting forces, the action of the force can be doubled. Besides the calculation of the gravitation of the pendulum bob towards the attracting masses, which is common to all methods, two measurements are necessary—the distance of the extra weights, and of the center of the pendulum bobs from the knife edge. Dr. Wilding believes that a more perfect apparatus, which is being constructed for him by Repsold of Hamburg, will give excellent results.—*Phil. Mag.*, March, 1885, pp. 219–222. J. T.

8. *Method of studying the Electrical Potential of the air.*—M. Pellat has discovered in common with all who have used Thomson's water dropper, that this apparatus does not take the potential of the air quickly. With a discharge of 8 liters of water in twelve hours, six minutes were necessary in order to obtain $\frac{8}{10}$ of the variation of potential; and with a discharge of 12 liters, five minutes were needed to reduce the apparatus to the potential of the air. The slow match soaked in a preparation of lead, sometimes used in place of the water dropper, is less rapid in its indications than the water dropper, and moreover communicates its own potential due to combustion. This fault makes its use very undesirable for observations on atmospheric electricity. M. Pellat therefore has been led to employ as a substitute for a water dropper a small gas flame issuing from a metallic burner which is insulated from the ground and is connected with an electrometer. This burner takes the potential of the air almost instantaneously. In order to study the electrometric forces arising from the combustion of different gases, M. Pellat placed the gas burner inside a hollow metallic vessel, closed at the top and provided with holes necessary for draft; the metallic burner and the outside vessel were connected with a wire. This apparatus serves as a battery, there being an electromotive force developed, which depends: 1. Upon the nature of the gas which is burned; 2. Upon the nature of the metal of the burner, and 3. Upon the

nature of the metal which constitutes the internal surface of the surrounding vessel.—*Comptes Rendus*, No. 10, March 9, 1885, pp. 735–737. J. T.

9. *Measurement of Magnetic Force by hydrostatic pressure.*—Magnetic fluids under the influence of magnetic force show a pressure perpendicular to the magnetic lines of force, which is expressed by the equation $p=\frac{K}{8\pi}H^2$, in which H is the strength of the magnetic field, and K is a diamagnetic constant. The diamagnetic constant for atmospheric air is 1. When a magnetic fluid is surrounded by air, the difference of the magnetic pressure in the fluid and the air can be balanced by a hydrostatic pressure and can be measured by $K-1$. G. Quincke contributes a voluminous article on measurements of this character to the Annalen der Physik. The paper contains many tables of the results of measurement. The paper also contains tables of the quantity which G. Wiedemann has termed Atom Magnetism.—*Ann. der Physik und Chemie.* No. 3, 1885, pp. 347–416. J. T.

10. *A Selenium Actinometer.*—For the purpose of measuring the relative intensities of sunlight at different heights above the horizon, M. H. Morige has employed a selenium cell similar to that invented by Mr. Graham Bell. Thirty-eight discs of copper are insulated from each other by discs of mica of smaller radius; the groove thus formed is filled with selenium by being rubbed with a rod of this substance. The cylinder being suitably heated, this selenium is ready for use. The even numbers of copper are connected by one conductor and the odd numbers by another. The selenium cylinder is insulated by glass supports in the interior of a glass cylinder which is exhausted. The apparatus is placed high enough to avoid the light reflected from neighboring objects and the axis of the cylinder is placed parallel to the earth's axis. A constant current is passed through the selenium cells, and the instrument is calibrated by making measurements at first in a perfectly dark room.—*Comptes Rendus*, Feb. 2, 1885, pp. 271–272. J. T.

11. *Measurement of the Force of Gravity at Naha and Kagoshima, Japan.*—Messrs. S. Sakai and E. Yamaguchi have conducted a series of pendulum observations with the object of obtaining the data for a comparison of the acceleration due to the force of gravity at Naha (Okinawa) in the Loo Choo Islands with that at Tokio. The methods followed were essentially those followed by Mendenhall in his observations on Fujinoyama (see this Journal, xx, 124; xxi, 99). Experiments were also made by the party at Kagoshima on their way to Naha. The results obtained in c.g.s. units, as the mean of independent series with two pendulums were:

For Naha,	$g=979{\cdot}165\pm0{\cdot}0055$
For Kagoshima,	$g=979{\cdot}561\pm0{\cdot}0057$

Both values are somewhat greater than those deduced from the usual formula. Mendenhall obtained for Tokio $g=979{\cdot}854\pm0{\cdot}0044$.

12. *A Method of Measuring the Absolute Sensitiveness of Photographic Dry Plates*,* by WILLIAM H. PICKERING.—Within the last few years the subject of dry plate photography has increased very rapidly, not only in general popularity, but also in importance in regard to its applications to other departments of science. Numerous plate manufacturers have sprung up in this country as well as abroad, and each naturally claims all the good qualities for his own plates. It therefore seemed desirable that some tests should be made which would determine definitely the validity of these claims, and that they should be made in such a manner that other persons using instruments similarly constructed would be able to obtain the same results.

Perhaps the most important tests needed are in regard to the sensitiveness of the plates. Most plate makers use the wet plates as their standard, giving the sensitiveness of the dry plates at from two to sixty times greater; but as wet plates vary quite as much as dry ones, depending on the collodion, condition of the bath, etc., this system is very unsatisfactory. Another method employed largely in England, depends on the use of the Warnerke sensitometer. In this instrument the light from a tablet coated with luminous paint just after being exposed to a magnesium light, is permitted to shine through a colored transparent film of graduated density upon the plate to be tested. Each degree on the film has a number, and, after a given exposure, the last number photographed on the plate represents the sensitiveness on an empirical scale. There are two or three objections to this instrument. In the first place, the light-giving power of the luminous tablet is liable to variations, and, if left in a warm, moist place, it rapidly deteriorates. Again, it has been shown by Captain Abney that plates sensitized by iodides, bromides and chlorides, which may be equally sensitive to white light, are not equally affected by the light emitted by the paint; the bromides being the most rapidly darkened, the chlorides next, and the iodides least of all. The instrument is therefore applicable only to testing plates sensitized with the same salts.

In this investigation it was first shown that the plates most sensitive for one colored light were not necessarily the most so for light of another color. Therefore it was evident that the sun must be used as the ultimate source of light, and it was concluded to employ the light reflected from the sky near the zenith as the direct source. But as this would vary in brilliancy from day to day, it was necessary to use some method which would avoid the employment of an absolute standard of light. It is evident that we may escape the use of this troublesome standard, if we can obtain some material which has a perfectly uniform sensitiveness. For we may then state the sensitiveness of our plates in terms of this substance regardless of the brilliancy of our source. The first material tried was white filter paper, salted and sensitized in a standard solution of silver nitrate. This was afterward replaced

* From the Proceedings of the Academy of Arts and Sciences.

by powdered silver chloride, chemically pure,—which was found to be much more sensitive than that made from the commercial chemicals. This powder is spread out in a thin layer, in a long paper cell, on a strip of glass. The cell measures one centimeter broad by ten in length. Over this is laid a sheet of tissue paper and above that a narrow strip of black paper, so arranged as to cover the chloride for its full length and half its breadth. These two pieces of paper are pasted on to the under side of a narrow strip of glass which is placed on top of the paper cell. The apparatus in which the exposures are made consists of a box a little over a meter in length, closed at the top by a board, in which is a circular aperture 15·8 cm. in diameter. Over this board may be placed a cover, in the center of which is a hole ·05 cm. in diameter, which therefore lets through ·00001 as much light as the full aperture. The silver chloride is placed at a distance of just one meter from the larger aperture, and over it is placed the photographic scale, which might be made of tinted gelatines, or, as in the present case, constructed of long strips of tissue paper, of varying widths, and arranged like a flight of steps; so that the light passing through one side of the scale traverses nine strips of paper, while that through the other side traverses only one strip. Each strip cuts off about one sixth of the light passing through it, so that, taking the middle strip as unity, the strips on either side taken in order will transmit approximately,—

1	2	3	4	5	6	7	8	9
2·0	1·65	1·4	1·2	1·0	·85	·7	·6	·5

The instrument is now pointed toward the zenith for about eight minutes, on a day when there is a bright blue sky. On taking the apparatus into the dark room, and viewing the impression by gas-light, it will be found that the markings, which are quite clear at one end, have entirely faded out by the time the middle division is reached. The last division clearly marked is noted. Five strips cut from sensitized glass plates, ten centimeters long and two and a half in width, are now placed side by side under the scale, in the place of the chloride. By this means we can test, if we wish, five different kinds of plates at once. The cover of the sensitometer containing the ·05 cm. hole is put on, and the plates exposed to sky light for a time varying anywhere between twenty seconds and three minutes, depending on the sensitiveness of the plates. The instrument is then removed to the dark room, and the plates developed by immersing them all at once in a solution consisting of four parts potassium oxalate, and one part ferrous sulphate. After ten minutes they are removed, fixed and dried. Their readings are then noted, and compared with those obtained with the silver chloride. The chloride experiment s again performed as soon as the plates have been removed, and the first result confirmed. With some plates it is necessary to make two or three trials before the right exposure can be found,

but if the image disappears anywhere between the second and eighth divisions, a satisfactory result may be obtained.

The plates were also tested using gas-light instead of daylight. In this case an argand burner was employed burning 5 cubic ft. of gas per hour. A diaphragm 1 cm. in diameter was placed close to the glass chimney, and the chloride was placed at 10 cm. distance, and exposed to the light coming from the brightest part of the flame, for ten hours. This produced an impression as far as the third division of the scale. The plates were exposed in the sensitometer as usual, except that it was found convenient in several cases to use a larger stop, measuring ·316 cm. in diameter.

The following table gives the absolute sensitiveness of several of the best-known kinds of American and foreign plates, when developed with oxalate, in terms of pure silver chloride taken as a standard. As the numbers would be very large, however, if the chloride were taken as a unit, it was thought better to give them in even hundred thousands.

SENSITIVENESS OF PLATES.

Plates.	Daylight.	Gas-light.
Carbutt Transparency	·7	
Allen and Rowell	1·3	150
Richardson standard	1·3	10
Marshall and Blair	2·7	140
Blair Instantaneous	3·0	140
Carbutt Special	4·0	20
Monroe	4·0	25
Wratten and Wainwright	4·0	10
Eastman Special	5·3	30
Richardson Instantaneous	5·3	20
Walker Reid and Inglis	11·	600
Edwards	11·	20
Monckhoven	16·	120
Beebe	16·	20
Cramer	16·	120

It will be noted that the plates most sensitive to gas-light are by no means necessarily the most sensitive to daylight; in several instances, in fact, the reverse seems to be true.

It should be said that the above figures cannot be considered final until each plate has been tested separately with its own developer, as this would undoubtedly have some influence on the final result.

Meanwhile two or three interesting investigations naturally suggest themselves: to determine, for instance, the relative actinism of blue sky, haze and clouds; also, the relative exposures proper to give at different hours of the day, at different seasons of the year, and in different countries. A somewhat prolonged research would indicate what effect the presence of sun-spots had on solar radiation,—whether it was increased or diminished.

II. Geology and Mineralogy.

1. *Glacial deposits of Central North America in the Vicinity of the Bow and Belly Rivers, Canada;* by George M. Dawson, (Geol. Rep. Canada, 1882–84).—The facts here presented by Mr. Dawson are of great interest in their bearing on the glacial history of the continent. The region especially described is just north of the United States boundary, between the meridians of 110° W. and 115° W., and about 15° of longitude west of Winnipeg. The surface rocks are of the Cretaceous and Laramie series; and on its western border, in longitude 115°, the Rocky Mountain country commences and the rocks change to Paleozoic—the Carboniferous and Devonian formations overlying the Cambrian—without any crystalline rocks. Drift covers the whole region, and averages at least 100 feet in thickness. It consists of (1) a lower bowlder clay resting on quartzyte shingle; (2) an interglacial deposit with peat; (3) upper bowlder clay, above which are stratified sands, gravels and silts. The lower bowlder clay in the section given, 80 feet thick, contains a "variable and often very considerable proportion of Laurentian and Huronian erratics," or material from the eastern water-shed, along with quartzyte fragments from the Rocky Mountains on the west, and sandstone from the Cretaceous and Laramie. The interglacial beds in the same section (at Wolf Island), are 18 feet thick, and the upper bowlder clay, having traces of stratification, 40 feet. Moraines are also described as occurring along the base of the Rocky Mountains, and the Bow River valley as holding a glacier of larger size than any elsewhere originating in the mountains of the district.

Mr. Dawson observes also that south of the 49th parallel the country from Fort Benton, on the Missouri along the MacLeod trail, is all more or less thickly strewn with Laurentian erratics. Quartzyte material from the Rocky Mountains is most abundant south of the Morris River, but with it are granites, gneisses and other Laurentian and Huronian rocks from the eastward; some at a height of 4,390 feet; 20 miles north of 49°, at 5,280 feet; near the intersection of the 113th meridian and the 49th parallel at 4,200; one Huronian bowlder near the lower part of Watertown River, 3,200 to 3,300 feet in elevation above the sea, measuring 42×40×20 feet, and another 42×30×22, and consequently exceeding a thousand tons in weight.

Mr. Dawson presents the following views with regard to the mode of glaciation of the region.

"Apart from the local glaciers of the Rocky Mountains, it is evident that the glaciation has been accomplished by some agent moving westward or southwestward from the Laurentian axis which bounds the region of the Great Plains to the east. This agent has carried with it great quantities of Laurentian and Huronian material, which in the vicinity of the 49th parallel reaches at its extreme limit a point over 700 miles distant from

the nearest exposures of the parent rock, and to an elevation more than twice as great as that attained by any part of the Laurentian area. To explain this latter fact it seems now almost certain that we must assume that the western region was, in glacial times, relatively to the Laurentian area more depressed than at present. As I have elsewhere, in the publications before referred to, discussed at some length the question whether a glacier or floating ice best accounts for the facts, it is not here proposed to recapitulate the arguments. Two theories only, however, seem tenable. Either a great confluent glacier, occupying the Laurentian highlands or passing over them from the Hudson's Bay region, stretched continuously to the slopes of the Rocky Mountains, or such a glacier, extending but a limited distance from these highlands, supplied numerous and massive icebergs which floated in a great inland sea occupying the present position of the plains.

"I still believe that the latter supposition best accounts for the facts of the glaciation and glacial deposits of the plains. I would, however, point out one circumstance which seems to give some color to the former hypothesis. This is the existence of a number of *wide, old, abandoned water-channels*, which may be supposed by this theory to have carried the drainage of the country, and water produced by the melting of a great glacier of the kind implied, round its front at different periods in its retreat. The existence of these I am unable otherwise satisfactorily to explain, except on the supposition of considerable relative changes of level of different parts of the district in post-glacial times. Mr. Warren Upham has lately traced a number of such channels in Dakota (hypothetically extending his reasoning also to western Manitoba), for which he accounts by the first-mentioned or great-glacier theory.

"In the southern part of the district of the present report, and particularly in the country south of the Belly River, great old channels of the kind above referred to are displayed in a very striking manner in Verdigris, Etzi-kom, Pā-kow-kī and Chin Coulées and their tributaries. These resemble old river valleys long disused and now carrying little or no water. I am inclined to regard them as a portion of the earliest drainage system of the plains, outlined at the time at which the waters which distributed the stratified materials overlying the bowlder-clays first subsided, and when the rainfall of the region was considerably greater than at present. That these first channels have not, in the particular part of the region now referred to, continued to be the drainage-channels of the country is perhaps in part due to the much greater depth and importance rapidly attained by the valleys carrying copious and perennial streams derived from the mountains.

"In the entire obliteration of the original southeastward slope of the valleys of Verdigris and Pā-kow-kī Coulées, and other peculiar circumstances referred to in a previous part of this

report (p. 14 c), in connection with their present aspect of Milk River, as well as in several local details respecting the relations of the present drainage and the old channels, we appear to find evidence of *a greater amount of elevation of the southern as compared with the northern part of the district.** So far as it has affected these old drainage-channels this must have occurred in immediately post-glacial times, and may have been a continuation of the same process which has resulted in the present much greater elevation of erratics in the southern as compared with the northern part of this region.

"Unless explained by relative differences in level during the Glacial period, such as those above suggested, between the Bow River country and that near the 49th parallel, the absence of Laurentian erratics over the region west of Calgary can be accounted for only by the existence of Rocky Mountain glaciers of sufficient size in this region to fend off the eastern glaciating agent. It is not improbable that such glaciers obtained, and if they can be proved to have existed, it would also prove, in the most convincing way, the approximate contemporaneity of action of the glaciating agents of the Rocky Mountains and Laurentian region. It is certain, however, that the glaciers of the mountains had somewhat decreased before at least the final period of dispersion of Laurentian erratics, for these have been found overlying distinct morainic material of Rocky Mountain origin.

"That *the elevation of the western as compared with the eastern part of the plains, was relatively much less in Glacial times than at present*, seems a reasonable supposition, but must be regarded no longer as merely an hypothesis, for the position of the interglacial materials in the bowlder-clay offers a strong positive argument in its favor. It must be supposed that these beds, from their finely stratified character and evidences of tranquil deposit, were laid down, not along the gradually retreating edge of a lake, but in the bottom, and at depths not very considerable. This being the case, the deposits give us the means of recognizing a surface—that of the lake bottom—which was at least proximately horizontal during the interglacial period at which they were formed. From Wolf Island to Coal Banks, the two points farthest apart at which the deposits were observed, is a distance of forty-five miles in a direct line, on a bearing of about S. 70° W. The height above the river of the deposits at the former locality is seventy feet, at the latter, one hundred and five feet, giving a slope eastward of 0·77 feet per mile in addition to that of the present river bed. The latter may be assumed as indicating that of the present surface of the country, as a whole.

"The elevation of the beds in the intermediate Drift-wood bend section is about ninety-six feet, but the locality is only about six miles westward on the same line, and the resulting slope per mile is 4·3 feet, in addition to that of the river, in the same easterly direction, a rate of fall locally much greater than that above determined for the whole distance.

* See also Geology and Resources of the 49th Parallel, p. 264.

"The rate of fall of the Belly River, by its course, between Coal Banks and its mouth, is 6·8 feet to the mile, but on the line above defined (which is that of its general direction) between Wolf Island and Coal Bank, 12 feet to the mile. Adding the general slope previously ascertained for the intercalated beds, we find their eastward inclination to be 12·77 feet to the mile.

"The general eastward slope of the plains from the base of the mountains to that of the Laurentian region at Lake Winnipeg is about 5 feet to the mile, but the elevation increases more rapidly westward and in the region now considered; and if the intercalated beds referred to were again brought back to horizontality, the plains between the mouth of the Belly River, and Coal Banks would become nearly horizontal also.*

"Besides the effect of the glaciation of the country on its soils and general features, a further result of economic importance in connection with this period is *the distribution of gold.* Dr. Selwyn in 1874† expressed the belief, based on an examination of the country near Edmonton, that the gold found in the rivers of the Great Plains has been derived from the Laurentian and Huronian region to the east, and not from the Rocky Mountains. The facts met with in the district now reported on, conclusively prove the correctness of the above statement. In favorable spots on all the streams of which the banks and beds show abundance of Laurentian and Huronian Drift, fine gold may be obtained, while beyond the edge of this drift in the immediate vicinity of the mountains, I have never been able to detect a 'colour.'"

2. *Elephant Pipes in the Museum of Natural Sciences, Davenport, Iowa*, by CHARLES E. PUTNAM. 40 pp. 8vo, 1885. Davenport.—This address, by the President of the Davenport Academy of Natural Sciences, was called forth especially by expressions of disbelief with regard to accounts of the discovery of "elephant pipes" of soft sandstone and "inscribed tablets" in Indian Mounds of Iowa, published in the Proceedings of the Academy. Mr. Putnam makes the following statements with regard to the finding of these objects.

The discoveries in question are two elephant pipes and three inscribed tablets. Of the latter the first two were found in what is known as Mound No. 3, on the Cook farm, adjoining the city of Davenport. The principal discoverer was Rev. Jacob Gass, a Lutheran clergyman, then settled over a congregation in Davenport. In this exploration Mr. Gass was assisted by L. H. Willrodt and H. S. Stoltzenau, with five other persons who were accidentally present during the opening of the mound. The discovery was made on January 10th, 1877. An exact and careful state-

*In the region west of the Missouri, the present inclined position of the Pliocene beds shows that since the time of their disposition that part of the region in the vicinity of the Rocky Mountains has been greatly elevated. It may well be that the eastward slope of the portion of the plains here treated of may have been produced as a result of the same great movement, and if so the facts above recorded would assign it a date subsequent to that of the glacial period.

† Report of Progress, 1873–74, p. 58.

ment of the facts connected therewith was soon after prepared by Rev. Mr. Gass, and read at an early meeting of the Davenport Academy. It was published, and may be found in its "Proceedings."* Upon the announcement of the discovery, the officers and many members of the Academy were early on the ground to verify the statements made by the discoverers. The gentlemen engaged in the exploration are well known, and held in high esteem; their testimony as to all essential facts is clear and convincing, and the circumstances narrated seem to fully establish the genuineness of these relics. That their statement contains only facts all who know them will not question, and that the mound from which the relics were obtained had not been previously disturbed is sufficiently established by their testimony. The authenticity of this discovery must therefore be conceded by every fair-minded inquirer.

The third inscribed tablet was found on January 30th, 1878, in Mound No. 11, in the group of mounds on Cook's farm, in the suburbs of Davenport, and in close proximity to the mound wherein the other tablets were discovered. That indefatigable explorer, Rev. J. Gass, was also present during these further researches, and had for his assistants John Hume and Charles E. Harrison, both members of the Academy, and well and favorably known in this community. The circumstances of this discovery, as narrated by Mr. Harrison, are published in the Proceedings of the Academy.† No suspicions whatever attach to this discovery, and the well-attested facts connected therewith establish beyond reasonable doubt, that, whether more or less ancient, the tablet was deposited at the making of the mound.

Of the elephant pipes in the museum of the Academy, one was discovered in March, 1880, in a mound on the farm of Mr. P. Hass, in Louisa County, Iowa, by Rev. A. Blumer, a Lutheran Clergyman from a neighboring city, and was by him donated to the Academy. Rev. J. Gass, Mr. F. Hass, and a number of workmen were present, assisting in the exploration. A detailed account of the finding, prepared by Rev. Mr. Blumer, is published in the Proceedings of the Academy.‡ From the social standing and high character of the principal discoverers, no question has been, or can be, successfully raised as to the authenticity of this discovery. The other elephant pipe was not "discovered" by Rev. J. Gass, but was obtained by him from a farmer in Louisa County, Iowa.§ This man found it while planting corn on his farm several years prior to that date, and attached no particular value to the relic, but had sometimes used it in smoking. A brief account of its finding is given in the Proceedings of the Academy. It will thus be perceived that there are no suspicious circumstances connected with either of these discoveries, but that the surrounding and well-authenticated

* Proceedings Davenport Academy of Natural Sciences, vol. ii, p. 96.

† Ibid, vol. ii, p. 221. Mr. Harrison is now Vice-President of the Academy.

‡ Ibid, vol. iii, p. 132.

§ Ibid, vol. iii, p. 349, note.

facts seems to sufficiently establish the genuineness of these interesting relics.

Mr. Duncan observes that "their authenticity established, archæologists will find in them strong corroborative testimony that man and the mastodon were contemporary on this continent."

The pamphlet closes with an appendix in which a figure is given of one of the elephant pipes. The form of the elephant and the large ears and trunk are unmistakable, but the tusks are wanting.

3. *The Mersey Tunnel;* by T. MELLARD READE, F.G.S.—All who are interested in the success of a great engineering work will be pleased to hear that the Mersey Tunnel is now completed under the river and arched in. This is cause for congratulation all round, and especially to Liverpool people, for it has been an undertaking of great boldness both in conception and execution.

Having ventured a prediction as regards the strata likely to be met with, in a paper "On the Buried Valley of the Mersey," published in the "Proceedings of the Liverpool Geological Society," as far back as 1872, I think it is well, now the work is secure beyond a doubt, to call attention to the actual facts. In my paper of 1872 I stated the grounds of my belief that, notwithstanding the prevailing opinion that a shelf of rock extends across from Seacombe Point to Prince's Dock, it would be found that there exists in the bed of the river between Liverpool and Birkenhead a "deep rock channel or gully filled with drift."

In a paper on the "Drift Beds of the Northwest of England," Part II (Quarterly Journal of the Geological Society, May, 1883), I restated this view; and in the columns of the Builder, February 4, 1882, I further called attention to and insisted upon it. I may may also add that my views were published in the face of two sections in my possession at the time (1872) which professed to give the actual surface configuration of the rocky bed of the river as ascertained by borings for the projected tunnels; one on the site of that now carried out, the other higher up the river, between the south end of the city and New Ferry, both of which showed a thick covering of rock over the tunnels the whole way across the river.

The actual facts are these. The tunnel works have shown that the rocky bed of the river at its deepest point is, some 300 yards from the Liverpool side, deeply buried in drift. About 100 yards of this gully or pre-glacial bed have been intersected by the upper part of the tunnel. Before this part was finally arched up I had permission from the engineers to inspect it, which I did in company with my friend, Mr. Frank Archer, of the firm of Messrs. Gill & Archer, solicitors to the company, who have done so much to insure the success of the undertaking. Mr. Archer, having a good knowledge of geology, has always felt the greatest interest in the geological aspects of the tunnel works. We found the upper part of the tunnel section was in stiff, hard, bowlder clay resting,

excepting in one place where there was a thin patch of yellow sand, upon the hard surface of the homogeneous Triassic rock. There was no doubt of the nature of the strata; the clay was of the true glacial-marine type, and numerous bowlders of granite, trappean rocks, and greywacke were strewn about,—specimens of these are now in Mr. Archer's possession. All that I saw were rounded, and not striated, having the character usually possessed by the lower beds of the low-level bowlder clay as described in the account of the Atlantic Dock excavations.

Liverpool, December 5, 1884.

4. *Notes respecting Metamorphism;* by J. J. STEVENSON (Proc. Amer. Phil. Soc., Dec., 1884).—Professor Stevenson mentions cases where upturned and folded beds have become metamorphic and others in similar condition remain unchanged. He speaks of Lower Silurian shales (Knox group) in Russell County, Va., very much twisted, and still unaltered; of the red Medina sandstone thrown into close folds on the east side of Evitt's Mountain, in Bedford County, Pa., for a distance of more than 1000 feet, without any appearance of change in the rock; and the Hudson and Utica shales, a little way off to the east, turned up on edge, and still not showing slaty cleavage. Other cases are mentioned where sandstones are turned to quartzytes; and in one, in the Elk Range, Central Colorado, the extent of change increases with the distance from the median line of the fold. Cases are mentioned, also, of great change, and of none or very little, at contacts with eruptive rocks. He refers to the coal changed to coke in the Trinidad coal field of Colorado and New Mexico against intruded sheets of basalt or dikes of trachyte; but, on the north slope of the Placer mountains, a narrow dike of basalt cuts through the Laramie beds, and along an exposure of 38 feet "no effect whatever has been produced on the coal even at the line of contact."

5. *A Reprint of Geological Reports and other papers on the Geology of the Virginias;* by the late WILLIAM B. ROGERS, LL.D., etc., Director of the Geological Survey of Virginia from 1835 to 1841; President of the National Academy of Sciences. 832 pp. 8vo, with cuts, plates, and a large geological map. New York, 1884: D. Appleton & Co.—Among the State geological surveys which were carried forward before 1842 no one was of greater importance than that of Virginia under the direction of Professor William B. Rogers. Begun in 1835, it was vigorously prosecuted to the close of the year 1841, when, although the work over the great State was far from complete, further appropriations were withheld with no provision even for a final report. The results obtained were of the highest importance as regards the mineral wealth of Virginia and American Geology, and of great interest to general geological science through the developments made with respect to the structure and origin of the Appalachians, its coal fields, and other subjects illustrated; but, unfortunately, the annual reports were to be found in very few libraries.

Mrs. William B. Rogers has conferred a great benefit on the science of the country by generously editing and issuing a volume containing these reports together with other later papers by their author on Virginia geology. They are reprinted just as they were originally published, with only such changes as Professor Rogers had himself made. But to them are added numerous colored stratigraphical sections—ninety in all—on seven large sheets which had never before appeared. These sections have special value on account of their exhibitions of the flexures of the Appalachian rocks, the positions of the coal strata, and various other stratigraphical points. To the report is added also a small colored geological map of the Virginias—then one Virginia—made from a manuscript map by Professor Rogers, but with some changes and additions to bring the map up to date. This small map, as the preface states, is to be followed before long, "after certain topographical surveys are completed," by a larger geological map.

The volume contains descriptions of fossil plants of the Mesozoic Red Sandstone, referred by Professor Rogers to the Oölite, with figures of three species (*Zamites obtusifolius*, *Tæniopteris magnifolia* and *Lycopodites uncifolius*) and five plates of shells of the Miocene Tertiary of Virginia.

The last paper of the volume is Professor Rogers's last communication to geological science—an account of an infusorial deposit which was passed through in an artesian boring at Fort Monroe at a depth between 558 and 570 feet below the surface. A section of the beds intersected is given; in its explanations the deposit is called Miocene, but the text makes it Eocene. The specimen was put into the hands of Mr. Samuel Wells, in 1875 for examination, and he reported that out of the 40 species found 29 were identical with those of the Richmond infusorial stratum which Professor Rogers had described fifty years before.

The work is a large one—832 pages in small type—and contains thereby a great amount of matter important to geological science, and much also on the mineral products of the State.

6. *Fulgurites in the High Alps.*—M. Brun describes in a recent number of the Archives des Sciences, etc., of Geneva, the discovery of fulgurites or lightning tubes by himself and others upon a number of mountain summits in the Alps, at elevations varying from 3,348 to above 4,000 meters. The observations are interesting in connection with the recent description by Diller of fulgurites from Mt. Thielson in Oregon (see this Journal xxviii, 252).

The fulgurites are found on the highest point of the mountain, or in one case on a ridge a few meters below the summit. The fused portion presents itself under various aspects, sometimes as a collection of glassy beads a fifth of a millimeter in thickness and covering several square centimeters of the rock; or again in hemispherical forms several millimeters in diameter and hollow within. Sometimes vitrified sinuous lines 10 to 12 centimeters in length and coming to a common center are observed. In

another case the walls of a small depression, 8mm in diameter, in the center of the surface of a block of gneiss were completely vitrified, in still another a pebble which projected from a pile of stones had been perforated as if by a bullet and the sides of the hole completely fused. The thickness of the glass formed is never more than ¼ to 1 millimeter, and the fused surface has no great extent. The mass of fused matter consequently does not exceed 0·1 to 0·5 grams; one fulgurite weighed only 0·122 grams. The glass formed is that which would naturally result from the fusion of the adjacent minerals. It is brilliant, with mammillary surface, conchoidal fracture, varying in color and transparency. The fulgurites on the Rymptischhorn were black, as was to be expected since the rock is rich in actinolite; others from the Ruinette were pale brown, the rock being a chloritic gneiss with feldspar predominating. Examined with the microscope the fulgurite shows the presence of numerous cavities, caused by the vapor of the water which moistened the rock surface at the moment of fusion; there are also numerous inclusions with regular form in the homogeneous vitreous mass, which are fragments of the minerals torn off but not fused. The glass exerts no action on polarized light. An analysis of a fulgurite from Mont Blanc de Seillon on the gneiss gave the following results:—

SiO_2	Al_2O_3	Fe_2O_3	CaO	MgO	Alkalies
65·73	19·59	5·57	3·03	1·71	[4·37] = 100

The analysis proves that the iron of the chlorite has been oxidized as was to be inferred from the dark color of the glass. M. Brun states that thus far fulgurites have been observed upon nine of the high peaks of the Alps, and adds that many more will doubtless be discovered if attention is directed to the subject.

7. *Paleontology of the Eureka District;* by CHARLES D. WALCOTT, U. S. Geological Survey, J. W. Powell, Director. 298 pp. 4to, with 24 plates.—Some of the results of Mr. Walcott's study of the Eureka fossils (his personal collections) are mentioned in a notice of the second Annual Report of the Geological Survey, in this Journal (xxvii, 65, 1884). In the volume now published the species are described in full, with a statement of such paleontological conclusions as the present state of the facts appeared to warrant. The species belong to the Cambrian and Lower Silurian, Devonian and Carboniferous. The Upper Silurian is not represented, or only by two fossils, *Halysites catenulatus* and a *Zaphrentis.*

The report makes out for the region over 60 Cambrian species, two-thirds of them Trilobites, and over 100 Silurian species, nearly half of which are new.

The number of species and genera is sufficient to enable the author to establish the important fact that the transition as regards life from the Cambrian to the Lower Silurian is gradual, and to make out approximate equivalency with the Wisconsin and New York formations. Between the Devonian of the region and that of eastern localities he finds parallelisms, yet with some

cases of a reversal of the previously known order of succession, and of wider stratigraphical range; as in the occurrence of the Tully limestone (Hamilton) species, *Orthis Tulliensis*, at the summit of the Devonian limestone, and of the Chemung species *Orthis impressa* associated with eastern Upper Helderberg species. There is also a commingling of Upper Devonian species with the Lower Carboniferous fauna.

An interesting discovery is that of Pulmoniferous mollusks of the genera Physa and Zaptychius in the Subcarboniferous.

8. *The Occidental Alps.*—M. LORY has given the results of his explorations in this region in the Bulletin of the Geological Society of France, ix, 652 (1881). He states that no break exists between the crystalline schists, gneiss, mica schists, hornblende schists, of the "terrain primitive" and the Silurian beds to the eastward, and at Outer Rhône, in the Valais, the distinction between them is made out with difficulty. This author divides the Alps into a sub-Alpine and four Alpine zones, limited by faults. Of these four, the *first*, or that of Mt. Blanc (with the Aiguilles Rouges, etc.), and the *fourth*, or that of Monte Rosa, contain crystalline rocks, which are of rare occurrence over the intermediate region. The crystalline schists of the *fourth* zone are, beginning with the upper, sericite schist, chlorite schist with alternations of hornblendic schist, mica schists with alternations of cipolin and granular limestones, well stratified granitoid gneiss. In the first zone the coal formation is sometimes conformable with the crystalline schists and sometimes not. The greatest displacements in the region occur between the Carboniferous beds and the Trias—or the Lias where the Trias is absent. The protogine of Mont Blanc is in normal superposition over the mica schists, and its "en eventail" structure is not due to a central anticlinal fold, but simply to a synclinal fold of the upper series of crystalline schists. The great faults separating the four zones existed already in the Carboniferous era. Another fault, that of Grésivaudan, separates the first Alpine chain from the Subalpine, and it was slowly formed between the Upper Oölite (the Callovian) and the Chalk, and produced a displacement of 2000 meters.—*Archives des Sci. Phys. et Nat.*, xiii, March 15, 1885.

9. *Communicações da Secção dos Trabalhos Geologicos de Portugal.* Tom. I, fasc. 1, pp. 1–168, 8vo., Lisbon, 1885.—The Geological Commission of Portugal has commenced the publication of an octavo series, the successive numbers of which are to contain the minor works of the survey and which are to be published as often as the articles are sufficient to form a fascicule. Part I of the first volume now issued contains ten papers, among which may be noted, one by A. Ben-Saude on the optical anomalies of isometric crystals, a subject to which he has already made important contributions; another by Macpherson on the ophites and teschenites of Portugal; several by P. Choffat, one of these is on the age of the granite of Cintra. This granite occurs in veins in the strata belonging to the lower parts of the Malm,

and is consequently more recent than that; from a survey of all the facts the author concludes that the granite belongs either to the upper Cretaceous or to the Eocene, but as it is impossible to decide between these he regards the expression post-Cenomanien granite, as more correct than tertiary granite.

10. *Rhinoceros and Hippotherium from Florida.*—Dr. LEIDY describes in the Proceedings of the Philadelphia Academy of Natural Sciences for 1885, p. 32, two teeth, one belonging to an extinct Rhinoceros, which he names *R. proterus* (whether of the subgenus *Aceratium*, *Aphelops* or others is not determinable without other parts of the skeleton); the other, to the genus *Hippotherium* (which includes three-toed horses from the Miocene and later Tertiary), naming it *H. ingenuum*.

The specimens occur, with fragments of a crocodile, a carnivore about the size of a fox, and a lama, in a deposit overlying the Vicksburg limestone of Eocene age; but of what precise period later than Eocene is doubtful.

A species, named *Hippotherium venustum* in Holmes's Pliocene fossils (1860, 105, pl. xvi), and earlier *Hipparion venustum* (Proc. Philad. Acad. Nat. Sci., 1853, p. 241), was from the Ashley River phosphate beds of South Carolina.

11. *Das Antlitz der Erde von* EDUARD SUESS, Zweite Abtheilung, pp. 311 to 778, 1885, Prag (F. Tempsky), and Leipzig (G. Freytag).—The first portion of Professor Suess's most interesting and suggestive monograph was noticed in this Journal a little more than a year ago (vol. xxvii, 151). The general design of the whole work was there given, and the relation of the successive parts into which the subject had been divided. The present part completes the first volume. It is devoted to a discussion of the mountain systems of the earth, the first three chapters of which subject were contained in part I. The Mediterranean, the deserts of Northern Africa, the mountains of India, the relation of the Alps to the Asiatic mountains, the mountains of the American Continent, are some of the subjects which are discussed. The completion of the work will be awaited with interest.

12. *Studies of some Japanese rocks.*—Dr. BUNDJIRO KOTÔ, of Tsu-wa-no, Iwami, Japan, has published, as his inaugural dissertation at Leipzig, the results of a careful study of a series of Japanese rocks—pyroxene andesite, basalt, diabase, granite, diorite, porphyrite. Among other points of interest he describes the pyroxene of the andesite as being in part pleochroic, in part not, though both are monoclinic, and the author concludes belong to the same species. An analysis of the pleochroic augite, separated by the Thoulet solution, afforded

SiO_2	Al_2O_3	Fe_2O_3	FeO	CaO	MgO	MnO
53·26	4·01	3·42	14·07	10·15	14·65	tr = 99·56

These andesites also contain sparingly hornblende which is altered on the margins to pyroxene.

13. *American Fossil Cockroaches.*—Prof. S. H. SCUDDER describes new fossil cockroaches in the Proceedings of the Philadel-

phia Academy of Natural Science, 1885, p. 34—two from the Carboniferous deposits of Mazon Creek, Illinois, for which two new genera *Promylacris* and *Paromylacris* are instituted; and eight from the Triassic of Fairplay, Colorado, of the genera *Spiloblattina* (new), *Oryctoblattina*, *Petrablattina* and *Poroblattina* (new).

14. *Silurian fossil Cockroach from Jurques in Northwestern France.*—M. C. BRONGNIART has announced the discovery of the wing of a cockroach, showing most of its nervures, in a piece of Middle Silurian Sandstone belonging to De Verneuil's collection. The wing is 25 mm. long. He proposes for it the name *Palæoblattina Douvillei*. Its geological position makes it older than the Scotch and Swedish scorpions.—*C. R.*, Dec. 29, 1884; *Ann. Mag. Nat. Hist.*, xv, 355, April, 1885.

15. *Geology of Southern Kansas.*—A paper in the Bulletin of the Washburn College Laboratory, Topeka, Kansas (vol. i, No. 3, 1885), by the editor, describes the geology of Southern Kansas. It is stated that the Dakota Group (of the Cretaceous) commences at Milan and is the main country rock through Harper county to Medicine Lodge, but is partly overlaid by Tertiary. Its most remarkable feature is its stratum of massive gypsum, 12 to 20 feet thick, which is continuous over an area of 500 square miles. It occurs in the Dakota beds, but to the west is mostly in the overlying Benton group, and later Cretaceous. This gypsum bed is distinct from another Kansas bed in the Permo-Carboniferous.

16. *Illustrations of the Fauna of the St. John Group, continued: on the Conocoryphea, with further remarks on Paradoxides*, by S. F. MATTHEWS. Trans. Roy. Soc. Canada, 1884, p. 99.—Mr. Matthews in his concluding remarks observes that the St. John beds are probably older than the other Cambrian areas of the Atlantic border, the Newfoundland and the eastern Massachusetts, and are best comparable in fauna with the oldest of the British Cambrian.

17. *Mineralogical Notes.*—Professor G. VOM RATH in a recent memoir (Bonn, 1885), describes and figures a number of the remarkable quartz crystals from Alexander and Burke counties, North Carolina, which had been placed in his hands for study by several American mineralogists. Of the North Carolina crystals in general, he says that in crystallographic interest they surpass the specimens of all other known localities of this most remarkable of minerals. They seem, he says, to embrace all the interesting features which have been described in crystals from other places. The general feature of the crystals is the occurrence of acute rhombohedrons, especially the rhombohedron 3R, with too the upper trapezohedral planes, particularly $-\frac{3}{2}$-$\frac{3}{2}$. The twin crystals also offer many peculiarities. Several new planes are given by vom Rath, for which, and other points of detail, however, reference must be made to the original paper.

The same pamphlet contains the description of a remarkable

crystal of stephanite from Mexico, tridymite in andesite from Krakatan; colemanite from California. (Compare this Journal, xxix, p. 34.)

18. *Bournonite; Cuprite.*—Mr. H. A. MIERS of the British Museum has recently published in the Mineralogical Magazine an exhaustive monograph on the crystallography of bournonite. To the accepted list of 50 forms, 29 well established new ones are added and 21 others which need confirmation. A table of upwards of 1000 angles gives all those which are important for the species.

The same author has observed upon Cornish crystals of cuprite planes of the hexoctahedron $\frac{3}{2}$–$\frac{9}{8}$ (986) developed in accordance with trapezohedral or gyroidal hemihedrism, a kind of hemihedrism long recognized as possible, but never before observed on natural crystals, and only once on artificial crystals (sal ammoniac).

19. *Lehrbuch der Mineralogie;* von Dr. GUSTAV TSCHERMAK, Zweite verbesserte Auflage. 597 pp. with 756 original figures and 2 colored plates. Vienna, 1885 (Alfred Hölder).—The first edition of Professor Tschermak's admirable Text-book of Mineralogy has already been noticed in these pages. Constant use of the book through the past year has served to confirm the first impression as to its value, which has been increased by the changes introduced into this new edition. It is remarkably clear and thorough in the theoretical portion and much originality both in matter and in manner of presentation. The descriptions of species are brief, sometimes almost too much so, but they are given in a form that renders them more than usually attractive to the average student. The large numbers of figures introduced are all from original drawings and in execution leave nothing to be desired.

20. *Fairfieldite from Bavaria.*—The rare mineral fairfieldite, hitherto known only from Branchville, Fairfield County, Conn., (see Brush and Dana, this Journal, xvii, 359), has been identified by Sandberger, at Rabenstein, Bavaria. Some years ago (Jahrb. Min., 1879, 370), he gave the provisional name leucomanganite to a supposed new phosphate from that locality. The discovery of additional material has enabled him to prove that this mineral is identical with fairfieldite, and the other name is accordingly withdrawn.

21. *Informe sobra las Especies Minerales del Estado de Jalisco per* CARLOS F. DE LANDERO. 41 pp. 8vo. Guadalajara, 1884.—This little pamphlet contains brief statements of the numerous minerals found in the State of Jalisco, Mexico. Similar accounts for the other Mexican States are to be desired.

22. *Smaltite from Colorado.*—In the analysis of smaltite on page 380 of volume xxiii, the percentage of iron should read 15·99 instead of 11·99 as there given.

III. Zoology.

1. *Elementary Text-Book of Zoology;* by Dr. C. Claus, translated and edited by Adam Sedgwick, with the assistance of F. S. Heathcote. 2 vols. 8vo, with numerous wood cuts. Macmillan & Co., New York, 1885.—This is an American edition of the English translation of the already well-known standard German text-book of Professor Claus. The editor has adhered very closely indeed to the original German text and has made very few additions, which are enclosed in brackets. In some respects a mere translation has its advantages, but as a current text-book of a science so eminently progressive, it is to be regretted that the able translator has not thought it best to make more numerous additions, in the form of foot-notes or otherwise, so as to bring the statements more nearly down to the actual state of the science in the year 1884, the date of the preface to the English edition. As a general thing most of the important discoveries made within the past five or six years are not referred to, and in other respects the book is not brought down to date. Even many of the important recent discoveries and investigations made in England are not in any way mentioned, and far less seldom is anything of American origin alluded to. In fact, the book, though in good English, is practically a German book still, and the books and authors quoted, or referred to as authorities in the lists of books to be consulted, are nearly all German, even when of less importance and value than other works in English and French, which are not mentioned. This is a peculiarity that we naturally expect in a German book, but it might easily have been remedied, to a great extent, by the editor, if he had chosen to add references to a considerable number of the more important books printed outside of Germany, and especially in the English language.

The appearance of the English translation will undoubtedly give this book a far wider circulation in England and America than it has hitherto had, and as a reference book for somewhat advanced students, it is, perhaps, unexcelled, even with the imperfections referred to, which are largely due to the fact that the book was written from a German point of view, and for German students, and has already been published some years in Germany.

About 180 pages of the first volume are devoted to the general facts of comparative anatomy and physiology, histology, embryology, reproduction of various kinds, evolution, etc. This part of the book will be of great interest and use to many who are not specialists in zoology, but who desire a general knowledge of the modern status of zoological biology. Chapter v, which treats briefly of evolution, Darwinism, etc., and the evidences for and against these theories, will be of more general interest, perhaps, than any other chapter.

The remainder of the two volumes is mainly devoted to systematic zoology, which is, in general, treated with great ability and skill.

As a matter of course, the classification adopted is capable of being criticised in many respects. But upon this subject zoologists are still very far from agreeing, so that every writer may, if he chooses, hold his own views of the classification of many portions of the animal kingdom. The first volume includes the Protozoa, Cœlenterata, Echinodermata, Vermes and Arthropoda. The rest of the groups are included in vol. ii.

The Arthropoda, and especially the Crustacea, are very fully treated in the first volume, while the greater part of the second is devoted to the Vertebrata (230 pages). The illustrations are very numerous (706) and are, for the most part, well selected and carefully engraved. A. E. V.

2. *Presence of eyes in the shells of certain Chitonidæ.* — Mr. H. N. Moseley, in the Quarterly Journal of Microscopical Science for January, 1885, states his discovery of eyes in the shell of certain Chitons, and describes and figures their microscopic structure and method of formation. They occur on the outer surfaces of the shells of some species of these mollusks, and are about $\frac{1}{175}$th inch in mean diameter. In *Schizochiton incisus*, the diameter is $\frac{1}{365}$th inch; the anterior shell has six rows of eyes and the posterior the same, the middle shells, two rows, with one exception, in which there are three. In other species the arrangement is different. In *Tonicia marmorata* the eyes of the anterior shell, in one specimen, lie in 34 radial lines, each line containing about 18 eyes.

The eyes have a convex cornea, a lens, and around the cornea a narrow zone of dark pigment which is the margin of the pigmented eye-capsule. Through the center of each cornea is seen a small circular area somewhat darker than the aperture of the pupil, but showing a brilliant spot of totally reflected light due to the lens. The soft structures of the eye lie in a more or less pear-shaped chamber, excavated in the surface of the tegmentum. The eye is sometimes prominent, and sometimes sunk in a shallow pit. Mr. Moseley figures the ramifications of soft tissue, which pass to the eyes and describes some of the branches as terminating in points, the papilliform bodies of Van Beneden, that probably are, according to Mr. Moseley, organs of touch, and are called by him megalæsthetes. The eyes are evidently to be regarded as modifications of megalæsthetes.

The forms of the Chitonidæ having well developed eyes appear to be mostly non-European.

IV. Miscellaneous Scientific Intelligence.

1. *Temperature for March.*—The Bulletin of the New England Meterological Society for March, 1885, contains the following statements in regard to the temperature during that month: "The month has been characterized by a greater amount of fair weather and less wind than is usual in March. Two features especially distinguish the month from the corresponding month

of former years, viz.: the small precipitation and the low temperature. The latter condition, added to the similar low temperatures of February and the last half of January, closes a season of remarkable severity. At Worcester, Mass., the continued cold is unexampled in the forty-seven years of continued observation, and it is probable that a similar result would be found at other stations, were the records examined. The observations at Gardiner, Me., Cambridge and Worcester, Mass., Providence, R. I., and New Haven, Conn., which cover a long succession of years, show that the average temperature of the three months, January, February, and March, 1885, was 5·2° below the average, and of the four months, December, 1884,—March, 1885, 3·3° below the average. The month closed with warmer weather, but the frost in the ground in southern New England extended to a depth of two or three feet, and good sleighing continued in the northern section.

"The unusually low average temperature of the month was the result of steady cold with but few single records of great severity. The temperature reached zero, however, at nearly all stations, as will be seen from Table II. The month was the coldest March on record at Gardiner, Me., Burlington, Vt., and Worcester, Mass., at which continuous records of nearly half a century have been consulted.

2. *Scientific Papers and Addresses of* GEORGE ROLLESTON, M.D., F.R.S., Linacre Professor of Anatomy and Physiology and Fellow of Merton College, Oxford, arranged and edited by William Turner, M.B., F.R.S., Prof. of Med. and Anat. Univ. Edinburgh, with a biographical sketch by Edward B. Tylor, F.R.S., Keeper of the Museum, Oxford. 2 vols., 948 pp., 8vo, with portrait, plates and wood-cuts. 1884, Oxford, (Clarendon Press, Macmillan & Co.).—Dr. Rolleston was a scholar of vigorous, independent, ever active mind, of wide range of knowledge, of brilliant and eloquent speech, and judiciously liberal in politics and everything else; a man who wrote "there is no subject so pleasing, and none so ennobling as the triumph of will over interest and the victory of conscience over expediency," and practiced accordingly. After a few years of work in the medical profession—nine months of it at the English hospital at Smyrna during the Crimean war—he was elected professor at Oxford in 1860. He died in 1881 in his 52d year. His scientific papers in the two volumes now published related to subjects in physiology; brain-anatomy; human and simian brains; craniology of the British Barrows or Bushmen, etc., excavations in ancient cemeteries in England with descriptions of skeletons and other archæological facts; also on subjects in zoology; with addresses on the modifications of aspects of organic nature produced by man; biological training and studies; the relative value of classical and scientific training; the earth-closet system; typhoid and enteric fever in Indian gaols, and on the relations of that disease and the cholera to the dry-earth system of conservancy; and other topics.

3. *Upon the formation of a deaf variety of the Human Race;* by ALEXANDER GRAHAM BELL. Paper presented to the National Academy of Sciences at New Haven, November 13, 1883. 86 pp. 4to.—Mr. Bell has here brought to bear his scientific precision and exact methods of investigation on a question of great importance to society. He concludes that the tendency to intermarriage of deaf mutes, from their congregation in asylums and being taught by signs only intelligible among themselves, promotes intermarriages and the increase in the number of deaf mutes, and urges that the schools for them should be small, and that instruction in articulation and speech-reading should take the place of signs.

4. *Prehistoric Fishing in Europe and North America;* by CHARLES RAU. 342 pp. 4to, with numerous cuts. Smithsonian Contributions to Knowledge, No. 509.—This volume contains a thorough report, with very numerous figures, of all that has been published on the implements, materials, boats, etc., used in fishing by prehistoric man, all stone pipes and other carvings, and pictures representing fishes and other animals of the water; and much about the modes of fishing, the shell-heaps, and other ethnological facts connected with the seashore Indians. It is full of matter of archæological value, all of which is presented in excellent style, with the best of woodcut illustrations representing the various objects described.

5. *Dictionary of Altitudes in the United States;* compiled by HENRY GANNETT, U. S. Geological Survey. 326 pp. 8vo.—A valuable volume of reference. It is essentially a new and enlarged edition of the work of Mr. Gannett published by the U. S. Geological Survey of the Territories in successive editions of the years 1873, 1875 and 1877.

Anales de la Oficina Meteorologia Argentina par du Director Benjamin A. Gould. Vol. iv, 600 pp. 4to. Cordoba, 1884.

The Lenâpe and their Legends, with the complete text and symbols of the Walam Olum, a new translation and an enquiry into its authenticity; by Daniel G. Brinton, A.M., M.D. 262 pp. 8vo. Brinton's Library of Aboriginal American Literature, No. V. Philadelphia. 1885.

The deflective effect of the earth's rotation; by W. M. DAVIS. Reprinted from the American Meteorological Journal. Vol. I, No. 12. 1885. (W. H. Burr Publishing Co., Detroit, Mich.) A brief and simple exposition of the subject.

The osteology of Amia calva, by R. W. Shufeldt, Rep. Comm. Fish and Fisheries for 1883. 90 pp. 8vo, with 14 plates.

Die Fauna des Iberger Kalkes, von J. M. Clarke. 94 pp. 8vo, with three plates of figures of fossils. Stuttgart, 1884. (N. Jahrb. f. Min. Geol. u. Pal., 1884).

Asteroidea, ved D. C. Danielssen og Johan Koren. 120 pp. large 4to, with 15 plates and 1 map. Den Norske Nordhavs-Expeditionen, 1876–1878. XI. Christiania, 1884.

Fourteenth Annual Report on the Geological and Natural History of Indiana for 1884. John Collett, State Geologist. Part 1st, Geology and Natural History, 122 pp. 8vo, with a colored geological map of the State; Part 2d, on the Post-Pliocene Vertebrates of Indiana, by Prof. E. D. Cope and James Wortman. 62 pp. 8vo, with 6 plates Indianapolis, 1884.

Bulletin of the U. S. National Museum; No. 27, Descriptive Catalogues Constituting a Report upon the Exhibit of the Fisheries and Fish-culture of the United States of America, made at the London Fisheries Exhibition, 1883; prepared under the direction of G. Browne Goode, U. S. Commissioner and a staff of associates. 1280 pp. 8vo. 1884. Washington.